THE DEVELOPMENT OF A MATHEMATICS PLACEMENT EXAMINATION FOR THE UNIVERSITY OF TENNESSEE AT MARTIN

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for the Degree of
SPECIALIST IN EDUCATION
July, 1975

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EXAMINATION FOR THE UNIVERSITY OF

TENNESSEE AT MARTIN

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PREFACE

This study is the development of a mathematics placement examination for The University of Tennessee at Martin. This mathematics placement examination is designed to identify each of the following: 1) students needing remedial mathematics work, 2) students requiring intermediate algebra prior to more advanced work, 3) students proficient in algebra but deficient in trigonometry, 4) students needing a review in algebra and trigonometry, and 5) students sufficiently proficient in college algebra and trigonometry to warrant their admission to calculus.

The forty-five minute UTM Mathematics Placement Examination consists of forty items. Scores are obtainable for arithmetic, algebra, trigonometry, arithmetic-algebra, algebra-trigonometry, and total. Subject area items are distributed throughout the test with items arranged in increasing difficulty. Students place their answers on IBM sheets. These sheets are then graded on the IBM 1230 Optical Scanner.

I wish to express my sincere gratitude to my thesis adviser and committee chairman, Dr. Vernon Troxel, for his continuous guidance and support. My appreciation is also expressed to the other members of the advisory committee, Dr. James Choike, Dr. Gerald Goff, and Dr. James Yelvington.

In conclusion, I express my appreciation to my wife, Judy, for her understanding and encouragement and the countless hours of typing.

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CHAPTER I

THE INSTITUTION

History

The University of Tennessee at Martin traces its origin to Hall-Moody Institute, established by the Baptists of Martin in 1900. It gained junior college status in 1927, when the state legislature passed a bill stipulating that the school be operated by The University of Tennessee at Knoxville. The University of Tennessee Junior College became a senior college in 1951. Named "The University of Tennessee Martin Branch," it offered bachelors degree programs in agriculture and home economics. In 1967, the institution officially became The University of Tennessee at Martin (UTM).

UTM now has five schools and two departments, with programs leading to the Bachelor of Arts and Bachelor of Science degrees. The school is accredited by the Southern Association of Schools and Colleges and is a member of the National Council for the Accreditation of Teacher Education and the Assembly of The American Association of Collegiate Schools of Business. The University of Tennessee at Martin is situated in Northwest Tennessee, about 125 miles northeast of Memphis and 135 miles northwest of Nashville in a small town of approximately 6,000 population.

Philosophy and Purpose

A major goal of the University of Tennessee at Martin is to provide superior quality undergraduate instruction in a wide range of disciplines. The primary aim of the faculty and staff of UTM is to provide an educational environment in which the individual student can realize his fullest potential. The University is committed to excellence in undergraduate education and to the development of a genuinely friendly, yet educationally stimulating, campus atmosphere that integrates the intellectual development of the student with other facets of his personality. As primarily a residential campus, UTM offers a wide range of opportunities that enrich and enhance the student's educational experiences outside the formal academic program.

The University's commitment to superior quality education goes beyond the traditional concern for imparting knowledge and developing intellectual skills. It also includes the sharpening of values, the fostering of moral sensitivity, and the development of a sense of personal responsibility. The kind of person ultimately produced as a result of the educational experience is the central concern of The University of Tennessee at Martin.

Students

Student Admission Requirements

Each student must be at least sixteen years of age. Each student must furnish satisfactory evidence of good moral character.

Usually, this is accomplished by a written recommendation from the high school principal. Each student must satisfy the following health requirements: (1) pass a physical examination by a licensed medical doctor, (2) have a tetanus immunization that is up-to-date, and (3) have an X-ray of the chest or a tuberculin test.

All entering freshmen are required to take the American College Testing Program and present their scores to the University. There are five general methods by which a student can gain admission to the University:

1) By presenting a diploma of graduation from an accredited high school together with the recommendation of the principal or counselor.

2) By passing entrance examinations. This criterion applies to students nineteen years of age or over who have not been graduated from a secondary school. Such students may be admitted to the University upon passing the high school level General Educational Development Test. These students may also be required to complete any high school units that are prerequisite to courses required in the college curriculum.

3) By submitting evidence of the studies successfully pursued in institutions of higher learning. A student transferring any credit from a junior college must complete the last 90 quarter hours credit offered for his degree in an accredited senior college if he uses the junior college credit toward

graduation. The last 45 quarter hours credit must be taken at UTM.

4) By qualifying as a special student. Special classification designates a person who desires to take undergraduate courses and gives satisfactory evidence of preparedness to take the subject open to him, but who does not plan to work toward a degree or diploma from the University.

5) By qualifying for early admissions. The University invites high school principals to nominate gifted students for admission at the end of their junior years in high school. In order to be eligible under this early admissions program, the gifted student must have a 3.50 high school average, a score at the 95th percentile or above on University norms on the American College Aptitude Test, the parents' consent, and the approval of his principal.

Before registration for each quarter, UTM has a week long orientation program in which all new freshman and transfer students are required to participate. The objectives of this orientation program, as Austin Patty (1966, pp. 184-188) points out, are threefold:

1) To help students become acquainted with all aspects of the institution and with other students.

2) To help students in their initial adjustment to the college environment so they may achieve satisfaction and belongingness.

3) To implement and facilitate administrative needs related to enrollment of new students.

Students in General

The University of Tennessee at Martin has an enrollment of approximately 5,000 students. The majority of these students come from rural areas within a 150 mile radius of Martin. However, there is an increasing number from the urban areas of Memphis and Nashville. The majority of out-of-state students come from Kentucky, Illinois, Georgia, Florida, New Jersey, Missouri, Mississippi, and Ohio. There are some foreign students with the majority of these coming from the regions of the Far East, Near East, and Latin America.

Brown and Thornton (1971, pp. 3-8) describe four diversities in student population that were developed by Clark and Trow and reported in Burton R. Clark's Educating the Expert Society. The first diversity is college subcultures, which include those students who are enrolled in college for a good time. The second category is nonconformist subcultures, which include those students who would like to burn the school down to achieve their goals. The third is vocational subcultures, which include those students who are looking for upward mobility. The fourth diversity is academic subcultures, which include those students who are serious in pursuing ideas beyond the minimum required for passing and graduation. These students identify with the college and its faculty. UTM general student body would be described by the writer's observations as having three of these four subcultures: the college, the vocational, and the academic.

Although UTM is a four year undergraduate institution, the students have many of the academic characteristics, socioeconomic backgrounds, self-concepts, interests and personality characteristics, reasons for attending college, and the educational occupational aspirations of both the junior college and four year college as discussed by K. Patricia Cross (1968, pp. 11-46).

Some of the academic and socioeconomic characteristics of UTM students are as follows:

1) The majority of students come from the upper 50 per cent of their high school classes. The median American College Test composite scores for entering freshman men and women are 20.05 and 19.14 respectively (Lacey, 1973).
2) Minority groups make up approximately 9 per cent of the student body (Lacey, 1973).
3) Fifty-two per cent of the students receive financial aid for their education through private scholarships or federal and state aid programs. The federal and state aid programs include student work study programs (Fron, 1973).
4) Twenty-eight per cent of the students are enrolled in the school of education, twenty-seven per cent in the school of liberal arts, eighteen per cent in the school of business, and ten per cent in the school of agriculture (Lacey, 1973).

The diverse regional, academic, and socioeconomic backgrounds of students, together with the open door admissions policy provide for a very heterogeneous body of entering students at the University of Tennessee at Martin. This heterogeneous body necessitated efforts at placing entering students in the appropriate courses, so that the students might have a chance to obtain a quality education in areas of their choice.

CHAPTER II

THE PROBLEM AND PREVIOUS RESEARCH

The University of Tennessee at Martin has very high failure and drop out rates for students enrolled in its mathematics courses. According to the Office of the Vice Chancellor of Academic Affairs at UTM, the Mathematics Department has the second highest rate on campus in both failures and drop outs in freshman courses. The rates vary from 20 to 55 per cent in each course per quarter. The UTM mathematics faculty believes that the present placement procedures, which are discussed below, are the chief causes of the high drop out and failure rates.

The UTM Mathematics Department offers freshman courses ranging from remedial mathematics (arithmetic and first year high school algebra) to calculus and analytic geometry. The mathematics requirement for admission to UTM is two years of high school mathematics, including at least one year of high school algebra. Any student who has a deficiency or lacks basic skills will take remedial courses Core Mathematics 1001 or Core Mathematics 1002, or both, before proceeding on the General Mathematics sequence 1110-1120-1130 or prerequisites to Calculus, College Algebra 1300 and Trigonometry 1040, or Precalculus Mathematics 1600. The General Mathematics sequence 1110-1120-1130 is a three, three-quarter hour sequence in mathematics designed to meet the mathematics requirements of those students who need three to nine quarter hours of mathematics to be graduated. Students are placed in General Mathematics 1110 if they meet the admission requirement in mathematics and if their major requires at least three to nine quarter hours of mathematics.

Mathematics 1810, Analytic Geometry and Calculus, is intended as the first mathematics course for students with superior backgrounds. Minimum high school mathematics preparation includes two years of algebra, one year of geometry, and one-half year of trigonometry (or an equivalent advanced mathematics course). In addition a student must meet one of the following requirements to be eligible to enroll in Mathematics 1810:

A) Score on the mathematics portion of the Standard ACT Test Battery of at least 27.

B) High school grade point average of at least a B, an average of B or better on all high school mathematics courses, and a strong desire to begin Calculus immediately.

Mathematics 1600, Precalculus Mathematics, is offered for students who do not meet criterion A or B above or who have serious reservations about their mathematics backgrounds. This course carries five hours credit. Two years of high school algebra is prerequisite and trigonometry is corequisite. Credit is not allowed for both Precalculus 1600 and Trigonometry 1040 or College Algebra 1300. A content description of the above courses can be found in

Appendix A. Mathematics 1810, Analytic Geometry and Calculus, will be denoted by Calculus 1810 throughout this paper.

The University of Tennessee at Martin has identified a need for improved placement procedures in mathematics. A placement examination appropriate for the diversified heterogeneous student body described in the previous chapter has been given first priority. This placement examination must be designed especially to identify each of the following:

1) Students needing remedial mathematics work
2) Students not adequately skilled in high school algebra and requiring training in intermediate algebra prior to more advanced work
3) Students sufficiently informed in intermediate algebra to be placed immediately in a college algebra course
4) Students proficient in algebra but deficient in trigonometry
5) Students needing a review of algebra and trigonometry
6) Students demonstrating sufficient ability in college algebra and trigonometry to warrant their admission to a course in analytic geometry and calculus.

The following sources were reviewed in the Winter of 1973 to find existing mathematics placement tests that would meet the needs of the UTM Mathematics Department.

1) Braswell, James S., Mathematics Tests Available in the United States, National Council of Teachers of Mathematics, Washington, D.C., 1972.

2) Buros, Oscar K., The Mental Measurements Yearbooks, The Gryphon Press, Highland Park, New Jersey.

3) Current Index to Journals in Education, CCM Information Corporation, 1969-1973.

4) Dissertation Abstracts International, A, The Humanities and Social Sciences, Xerox University Microfilms (Xerox Corporation), 1955-1973.

5) Educational Index, The H. W. Wilson Company, 1954-1968.

6) Educational Resources Information Center, U.S. Department of Health, Education, and Welfare/Office of Education National Center for Educational Communication, 1965-1973.

7) 101 college catalogs in the UTM Library.

From the educational resources and 101 college catalogs reviewed eleven colleges gave some indication that they had a placement program in mathematics. Therefore, letters of inquiry were sent to the following schools:

1) Austin Peay State University
Clarksville, Tennessee

2) Oklahoma Christian College
Oklahoma City, Oklahoma

3) Brevard Junior College
Cocoa, Florida

4) Marshall University
Huntington, West Virginia

5) Oakland Community College
Bloomfield Hills, Michigan

6) The University of Tennessee at Knoxville
(College of Engineering)
Knoxville, Tennessee

7) Daytona Beach Junior College
Daytona Beach, Florida

8) Staten Island Community College
New York, New York

9) Butler Community College
Butler, Pennsylvania

10) Southern Illinois University Tech Institute
Carbondale, Illinois

11) Lincoln Land Community College
Springfield, Illinois

Replies were received from:

1) Austin Peay State University

2) Brevard Junior College

3) Marshall University

4) Staten Island Community Junior College

5) The University of Tennessee at Knoxville (Engineering Department).

Austin Peay State University gave the Cooperative Mathematics Pre-Test but discontinued it a few years ago. They now place students on the basis of ACT test scores and high school records. Brevard Junior College counselors use the available Florida twelfth grade scores for graduates of Florida high schools to place incoming students. Marshall University utilizes the results of the American College Test for placement of entering freshmen and feels that this method of placement is generally successful. Staten Island Community Junior College has its outstanding modules program which it feels is successful. The Engineering Department at the University of Tennessee at Knoxville utilizes the ACT Mathematics Placement Examination during the summer orientation period. However, the cut off points were established several years ago, and no recent studies of scoring have been made.

The following standardized mathematics placement examinations were reviewed in the winter of 1973 to find existing mathematics placement tests that would meet the needs of the UTM Mathematics Department:

1) ACT Mathematics Placement Examination
(American College Testing Program, 1968)

2) Arithmetic Test for Prospective Nurses
(The Center for Psychological Service, 1949)

3) CLEP General Examination in Mathematics
(Educational Testing Service, 1972)

4) CLEP Subject Examination in College Algebra and Trigonometry
(Educational Testing Service, 1970)

5) Cooperative Mathematics Tests: Algebra I, II, & III
(Educational Testing Service, 1963)

6) Cooperative Mathematics Tests: Trigonometry
(Educational Testing Service, 1963)

7) Educational Skills Test College Edition Mathematics Test
(California Test Bureau, McGraw-Hill, 1971)

8) ERB Modern Elementary Algebra Test
(Educational Records Bureau, 1966)

9) ERB Modern Second Year Algebra Test
(Educational Records Bureau, 1969)

10) McGraw-Hill Basic Skills System Mathematics Test
(California Test Bureau, McGraw-Hill, 1970)

11) Purdue Industrial Mathematics Test
(The University Book Store, 1946)

12) STEP Series II Mathematics Basic Concepts
(Educational Testing Service, 1969)

The UTM freshman orientation period will allow only a sixty minute time period to administer a mathematics placement examination.

The above examinations were either too time-consuming to administer or not comprehensive enough to meet the needs of the UTM Mathematics Department. In like manner, the educational resources listed on the previous pages yielded no other placement tests or placement test programs that would meet the needs of the UTM Mathematics Department. Therefore the author decided to construct a mathematics placement examination to meet these needs.

CHAPTER III

PREPARATION AND DESCRIPTION OF A PLACEMENT TEST

To construct a mathematics placement examination that can be administered in sixty minutes and yet meet the six needs of the UTM Mathematics Department is a major task. Fifteen minutes of this sixty minute time period is necessary to pass out materials, give general directions, and collect the test materials. Therefore, a maximum of forty-five minutes is allowed for taking the placement examination. After thoroughly reviewing the needs of the UTM Mathematics Department, the UTM freshman mathematics courses, and the existing mathematics placement tests mentioned in Chapter II, the writer decided on three basic areas of concentration, arithmetic, algebra, and trigonometry, to ensure the appropriateness of the test for most students. Achievement is assessed in terms of students' comprehension of the basic concepts, techniques, and unifying principles in each content area. The student's ability to apply understanding of mathematical ideas to new situations and to reason with insight must be emphasized. Factual recall and computation must be minimized. However, these were only accomplished by proper test construction.

The UTM Mathematics Placement Examination was constructed using the procedures suggested by the test specialists Bloom (1956), Davis (1964), and Thorndike and Hagan (1961). The first step in the test construction was defining the objectives of the test, which are listed in Chapter II. The second step consisted of making an item content outline of all the topics to be tested. (See Table I.) This outline was then used to form a table in which the content categories and the entries under each served as row labels. The third step consisted of making a behavioral outline. The entries in this outline referred to the types of response behaviors through which the student was expected to demonstrate his knowledge of the content referred to by the row labels. The categories in the behavior outline were designed to represent the full range of complexity of cognitive processes which underlie the responses to the items that were constructed. The labels of the response categories included such phrases as define, simplify, factor, combine, graph, and solve. The resulting behavior categories were then used to label the columns of the table. The fourth step involved constructing test items for each of the cells in the table. Two to five test questions on each item category were written. The test questions were analyzed for the following maxims:

1) Low reading difficulty
2) No one item providing clues to the answer of another item or items
3) Interlocking or interdependent items avoided
4) Occurrence of correct responses followed a random pattern
5) Trick and catch questions avoided
6) Ambiguities in each item avoided.

The forty-five minute time limit and the writer's experience determined that the Pilot UTM Mathematics Placement Test would have thirty-nine questions. The thirty-nine questions representing all the content item categories were selected from the seventy-nine questions constructed from the table. The thirty-nine questions were made up of five arithmetic, twenty algebra, and fourteen trigonometry items. The final step in the test construction consisted of having two judges from the UTM Mathematics faculty review the entire procedure and the resulting test.

Thus a forty-five minute Pilot UTM Mathematics Placement Test was constructed. Subject area items were distributed throughout the test, and the items were arranged in increasing difficulty, based on the writer's judgment. The item numbers composing each part score are given in Table II. Scores were obtained for arithmetic, algebra, trigonometry, arithmetic and algebra, algebra and trigonometry, and total. The above combined scores were deemed as relevant by the writer since Core Mathematics 1002 is a combined arithmetic and algebra course, and Precalculus Mathematics 1600 is a combined trigonometry and algebra course. Also, the combined scores added another dimension in helping to place a heterogeneous body of students in courses ranging from remedial arithmetic to calculus. Each part score was the per cent correct. The per cent scores were used to compare the subtests on an equitable basis. Also, per cent scores are more familiar to the nonmathematical general reader. However, per cent scores have the same defects as raw scores. The Pilot UTM Mathematics Placement Examination was administered on the first day of classes during the spring quarter of 1973 to three General Mathematics 1110 classes, one General Mathematics 1120 class, one Precalculus Mathematics 1600 class, and one Calculus 1810 class. The enrollments in the General Mathematics 1110, General Mathematics 1120, Precalculus Mathematics 1600, and Calculus 1810 classes were 118, 41, 8, and 26 students respectively. The means and standard deviations on parts and total scores of the Pilot UTM Mathematics Placement Test are given in Table III. The main objective for this administration of the Pilot Test was to secure data for an item analysis.

To determine the merit of any test item, test results must be subjected to an item analysis. As a result of this analysis, three kinds of information were obtained concerning each item: (1) difficulty, (2) discrimination index, and (3) effectiveness of the distractors. The first of these, the difficulty of the item, is the proportion of individuals who answer the item correctly. The second, the discrimination index, is a measure of how well the item separates the upper and lower level students. The index is scaled from -1.0 to 1.0 with 0.0 as the poorest discriminator. A large positive index means that a high-scoring student is more likely to answer the questions correctly than is a low-scoring student. On the other hand, a large negative index means that the reverse is true. A question with an index near 0.0 does not discriminate between the upper and lower level students. In general, a question's power to discriminate is independent of its difficulty.

The exception to this is that questions of medium difficulty will tend to have higher indexes than questions which are extremely hard or extremely easy.

Each test item on the Pilot UTM Mathematics Test was analyzed with respect to its difficulty, discrimination index, and distractors. The General Mathematics 1110 and the General Mathematics 1120 classes were selected as sample groups to collect item data representing the students who have only a basic arithmetic and algebra background. The Precalculus Mathematics 1600 and the Calculus 1810 classes were used to collect item data to represent the students taking the Pilot Test who needed a more advanced mathematics background including trigonometry. The results for the difficulty and discrimination index of each test item given to the General Mathematics 1110 classes, General Mathematics 1120 classes, Precalculus Mathematics 1600 class, and the Calculus 1810 class are listed in Tables IV, VI, VIII, and X respectively. A question with one of the following conditions was rewritten: a) difficulty near zero or b) discrimination index near zero or negative. Table IV shows that the difficulty of each of the five arithmetic questions administered to the General Mathematics 1110 classes was above .63, except for question 21 which was .44. The difficulty of each of the five arithmetic items for the General Mathematics 1120 (Table VI) ranged from .54 to .98; Precalculus Mathematics 1600 (Table VIII) ranged from .50 to .88, except for question 21 with .25; and Calculus 1810 (Table X) ranged from .80 to .96. The discrimination index of each of the five arithmetic items for the

General Mathematics 1110 (Table IV) ranged from .23 to .59; Precalculus Mathematics 1600 (Table VIII) ranged from -.25 to .00, except question 8 with .25; Calculus 1810 (Table X) ranged from -.07 to .30 with question 3 having .30. Making use of the above data, the writer then rewrote all five arithmetic questions.

The difficulty of each of the twenty algebra questions for the General Mathematics 1110 (Table IV) ranged from .11 to .69, with questions 14, 20, 26, 33, and 38 between .11 and .20. However, nine of the twenty questions had a difficulty above .36. The difficulty of each of the twenty algebra questions for the General Mathematics 1120 (Table VI) ranged from .15 to .93 with questions 20, 26, and 33 having .17, .15, and .15 respectively. However, eleven of the twenty algebra questions had a difficulty above .44. The difficulty of each of the twenty algebra questions for the Precalculus Mathematics (Table VIII) ranged from .13 to .88, except question 33 with .00. Eight of these questions had difficulty .25 or lower. The difficulty of each of the twenty algebra questions for Calculus 1810 (Table X) ranged from .32 to .92, except questions 20, 26, and 39 with .24, .04, and .24 respectively. The discrimination index of each of the twenty algebra items for the General Mathematics 1110 (Table IV) ranged from .30 to .52, except five items which ranged from .18 to .28. The discrimination index of each of the twenty algebra items for General Mathematics 1120 (Table VI) ranged from .14 to .42 except four items with .90 and item 20 with -.04. The discrimination index of each of the twenty algebra items for Precalculus Mathematics 1600 (Table VIII) ranged from .25 to .75, except questions 11, 12, 15, 21, and 33 with .0 and 26 with -.25. The discrimination index of seven of the twenty algebra items for Calculus 1810 (Table X) ranged from .15 to .30. Six of the algebra items for Calculus 1810 (Table X) ranged from .15 to .30. Six of the algebra items for Calculus 1810 had a discrimination index of .07 and seven items had .00 or less. Based upon the above difficulty and discrimination indexes from the General Mathematics 1110, General Mathematics 1120, Precalculus Mathematics 1600, and Calculus 1810 samples the following algebra items were rewritten: 4, 11, 12, 13, 14, 15, 19, 20, 26, 27, 28, 33, 38, and 39.

The difficulty and discrimination index of the Precalculus Mathematics 1600 and Calculus 1810 were used to determine whether the trigonometry items should be rewritten. The difficulty of the fourteen trigonometry questions for Precalculus Mathematics 1600 (Table VIII) ranged from .13 to .38, except questions 22, 34, and 35 with .00. The difficulty of the fourteen trigonometry items for the Calculus 1810 (Table X) ranged from .16 to .36, except question 31 with .00. Eight of the items were above .28. The discrimination index of the fourteen trigonometry items for the Precalculus Mathematics 1600 (Table VIII) ranged from .25 to .50, except questions 18, 21, and 36 with .00. The discrimination index of the fourteen trigonometry items for the Calculus 1810 (Table X) ranged from -.30 to .15. Based upon the above difficulty and discrimination indexes all the fourteen trigonometry questions were rewritten.

In addition, each of the thirty-nine items on the Pilot UTM Mathematics Placement Test was analyzed with respect to the effectiveness of the distractors. The effectiveness of the distractors for General Mathematics 1110, General Mathematics 1120, Precalculus Mathematics 1600, and Calculus Mathematics 1810 was listed in Tables V, VII, IX, and XI respectively. Only question one of the General Mathematics 1110 sample (Table V) had a distractor of .00 proportion. The items of the General Mathematics 1120 sample (Table VII) had eight items with one distractor of .00 proportion, one item with two distractors of .00 proportion, and one item with three distractors of .00 proportion. Every item of the Precalculus Mathematics 1600 sample (Table IX) had at least one distractor of .00 proportion. Thirteen of the thirty-nine items of the Calculus 1810 sample (Table XI) had at least one distractor of .00 proportion.

In summary, as a result of the item analysis with respect to difficulty, discrimination index, and the effectiveness of the distractors all thirty-nine items on the Pilot UTM Mathematics Placement Test were rewritten and improved. These results can be found in Chapter V. Also, to improve the Mathematics Placement Examination for placing remedial students, the writer added an arithmetic question about ratio. The addition of the ratio question made a total of forty questions on the Mathematics Placement Examination.

A description of the UTM Mathematics Placement Examination to be considered is as follows. The forty-five minute mathematics placement examination consists of 40 items. All questions are multiple choice with five alternatives. The per cent correct scores are obtainable for arithmetic, algebra, trigonometry, arithmetic-algebra, algebra-trigonometry, and total. Subject area items are distributed throughout the test with the items arranged in increasing difficulty. The item numbers composing each part score are given in Table XII. A detailed description of the content of the UTM Mathematics Placement Examination is given in Table XIII. Students place their answers on IBM sheets. These sheets are then graded on the IBM 1230 Optical Scanner. The UTM Mathematics Placement Examination is in Appendix B.

TABLE I

ITEM CONTENT CATEGORIES

Part
Arithmetic
Addition of fractions
Division of fractions
Signed numbers
Percentage
Algebra
Algebraic substitution
Solutions of linear and quadratic equations
Simplification and factoring of algebraic expressions
Graphs of linear equations
Solution of simultaneous linear equations in two unknowns
Exponents involving positive and negative integers
Solutions of exponential equations
Complex numbers
Functional notation
Radicals
Simplification of algebraic fractions
Slope of a line
Trigonometry
Definition of trigonometric functions
Solution of triangles
Identities
Inverse functions
Period of trigonometric functions
Solution of trigonometric equations

TABLE II

ITEMS COMPOSING EACH PART SCORE OF THE PILOT UTM MATHEMATICS PLACEMENT EXAMINATION

Part Score	Item Numbers	% of Total
Arithmetic	1, 2, 3, 8, 21	12.8
Algebra	4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 19, 20, 26, 27, 28, 32, 33, 38, 39	51.3
Trigonometry	16, 17, 18, 22, 23, 24, 25, 29, 30, 31, 34, 35, 36, 37	35.9
TOTAL		100

TABLE III

MEANS AND STANDARD DEVIATION ON PARTS AND TOTAL SCORES OF PILOT UTM MATH PLACEMENT TEST, SPRING, 1973

Course	No. of Students	Arithmetic 5 items		Alg. 20 items		Trig. 14 items		Arith.-Alg. 24 items		Total 39 items	
		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
1110	118	68.6	24.4	34.7	17.9	14.9	13.4	40.8	16.7	31.6	13.3
1120	41	81.9	16	49.1	18.9	18.4	14.4	53.6	16.1	42.0	13.5
1600	8	67.5		40.6		15.17		42.5		34.5	
1810	26	88.0	15.2	55.1	17.5	23.7	9.8	58.3	14.9	47.7	9.7

TABLE IV

PILOT GENERAL MATHEMATICS 1110 SAMPLE: ITEM DIFFICULTY AND ITEM DISCRIMINATION INDEX

Question No.	Correct Answer	Difficulty	Discrim. Index
x 1	E	.796	.23
x 2	A	.771	.30
x 3	B	.635	.59
4	C	.381	.52
5	B	.584	.37
6	A	.567	.52
7	B	.644	.30
x 8	B	.788	.33
9	C	.686	.44
10	E	.364	.49
11	D	.449	.28
12	C	.381	.37
13	B	.516	.50
14	E	.186	.47
15	B	.245	.59
. 16	D	.076	.20
. 17	B	.203	.18
. 18	E	.076	.22
19	B	.338	.37
20	A	.177	.27
x 21	A	.440	.40
. 22	A	.135	.25
. 23	E	.144	.06
. 24	E	.059	.20
. 25	B	.084	.15
26	C	.110	.33
27	C	.271	.18
28	B	.161	.35
. 29	B	.177	.28
. 30	C	.203	.20
. 31	B	.161	.16
32	A	.330	.50
33	C	.135	.23
. 34	C	.186	.15
. 35	C	.262	.16
. 36	B	.161	.03
. 37	C	.203	.28
38	C	.203	.22
39	D	.211	.28

x = arithmetic question no mark = algebra question $\overline{X} = 36.5$
. = trigonometry question SD = 13.3

TABLE V

PILOT GENERAL MATHEMATICS 1110 SAMPLE
EFFECTIVENESS OF DISTRACTORS

Question No.	Correct Answer	Proportions A	B	C	D	E	Omit
x 1	E	.12	.00	.02	.05	.79	.00
x 2	A	.77	.16	.02	.00	.00	.02
x 3	B	.02	.63	.14	.04	.15	.00
4	C	.08	.22	.38	.11	.16	.03
5	B	.29	.58	.04	.02	.04	.00
6	A	.56	.05	.35	.01	.00	.00
7	B	.08	.64	.19	.01	.02	.03
x 8	B	.14	.78	.00	.03	.01	.00
9	C	.05	.06	.68	.14	.04	.00
10	E	.06	.12	.19	.12	.36	.11
11	D	.23	.05	.12	.44	.08	.05
12	C	.12	.18	.38	.12	.05	.12
13	B	.17	.51	.07	.11	.08	.02
14	E	.02	.13	.59	.02	.18	.03
15	B	.20	.24	.14	.22	.16	.01
. 16	D	.28	.11	.28	.07	.05	.17
. 17	B	.08	.20	.17	.29	.04	.19
. 18	E	.22	.06	.33	.11	.07	.16
19	B	.24	.33	.13	.11	.08	.08
20	A	.17	.11	.16	.27	.10	.15
x 21	A	.44	.11	.14	.08	.05	.15
. 22	A	.13	.21	.24	.16	.05	.17
. 23	E	.12	.15	.19	.20	.14	.17
. 24	E	.31	.20	.11	.08	.05	.22
. 25	B	.05	.08	.28	.26	.02	.27
26	C	.20	.33	.11	.08	.20	.05
27	C	.16	.22	.27	.11	.07	.14
28	B	.34	.16	.05	.21	.13	.08
. 29	B	.16	.17	.17	.15	.09	.23
. 30	C	.10	.17	.20	.11	.14	.25
. 31	B	.15	.16	.15	.23	.05	.24
32	A	.33	.10	.08	.35	.06	.05
33	C	.09	.05	.13	.23	.37	.10
. 34	C	.05	.10	.18	.21	.16	.27
. 35	C	.06	.19	.26	.13	.05	.27
. 36	B	.11	.16	.20	.12	.08	.31
. 37	C	.11	.27	.20	.12	.06	.21
38	C	.18	.12	.20	.16	.11	.21
39	D	.24	.19	.14	.21	.05	.15

x = arithmetic question   no mark = algebra question $\bar{X}$ = 36.5
. = trigonometry question   SD = 13.3

TABLE VI

PILOT GENERAL MATHEMATICS 1120 SAMPLE: ITEM DIFFICULTY AND ITEM DISCRIMINATION INDEX

Question No.	Correct Answer	Difficulty	Discrim. Index
x 1	E	.975	.04
x 2	A	.902	.14
x 3	B	.829	.33
4	C	.609	.19
5	B	.731	.14
6	A	.731	.42
7	B	.804	.38
x 8	B	.853	.09
9	C	.926	.14
10	E	.512	.28
11	D	.487	.09
12	C	.512	.19
13	B	.829	.14
14	E	.292	.23
15	B	.341	.42
. 16	D	.121	.00
. 17	B	.195	.04
. 18	E	.121	-.04
19	B	.487	.09
20	A	.170	-.04
x 21	A	.536	.14
. 22	A	.268	.00
. 23	E	.243	.00
. 24	E	.170	.00
. 25	B	.146	.00
26	C	.146	.09
27	C	.439	.28
28	B	.317	.28
. 29	B	.219	.00
. 30	C	.195	-.19
. 31	B	.097	.00
32	A	.585	.23
33	C	.146	.23
. 34	C	.146	-.14
. 35	C	.170	-.09
. 36	B	.219	.09
. 37	C	.317	.09
. 38	C	.268	.28
39	D	.487	.23

x = arithmetic question no mark = algebra question $\overline{X}$ = 42.0
. = trigonometry question SD = 13.5

TABLE VII

PILOT GENERAL MATHEMATICS 1120 SAMPLE
EFFECTIVENESS OF DISTRACTORS

Question No.	Correct Answer	Proportions A	B	C	D	E	Omit
x 1	E	.00	.00	.00	.02	.97	.00
x 2	A	.90	.02	.02	.02	.00	.02
x 3	B	.02	.82	.07	.00	.07	.00
4	C	.09	.09	.60	.12	.02	.04
5	B	.19	.73	.00	.04	.02	.00
6	A	.73	.02	.17	.07	.00	.00
7	B	.04	.80	.07	.02	.04	.00
x 8	B	.09	.85	.02	.02	.00	.00
9	C	.02	.00	.92	.04	.00	.00
10	E	.02	.17	.17	.07	.51	.04
11	D	.17	.04	.31	.48	.04	.02
12	C	.09	.17	.51	.12	.04	.04
13	B	.09	.82	.04	.02	.00	.00
14	E	.04	.17	.48	.00	.29	.00
15	B	.12	.34	.14	.29	.09	.00
. 16	D	.14	.07	.48	.12	.02	.14
. 17	B	.07	.19	.29	.19	.04	.19
. 18	E	.14	.00	.43	.12	.12	.17
19	B	.12	.48	.14	.07	.09	.07
20	A	.17	.14	.12	.29	.04	.21
x 21	A	.53	.04	.24	.09	.00	.04
. 22	A	.26	.12	.19	.14	.07	.19
. 23	E	.09	.12	.07	.19	.24	.26
. 24	E	.19	.14	.09	.14	.17	.24
. 25	B	.00	.14	.21	.29	.02	.31
26	C	.14	.51	.14	.09	.07	.02
27	C	.29	.14	.43	.07	.02	.02
28	B	.14	.31	.04	.14	.29	.04
. 29	B	.21	.21	.09	.04	.17	.24
. 30	C	.17	.14	.19	.12	.14	.21
. 31	B	.31	.09	.12	.26	.02	.17
32	A	.58	.09	.02	.21	.02	.04
33	C	.07	.07	.14	.36	.19	.14
. 34	C	.09	.24	.14	.09	.12	.29
. 35	C	.07	.19	.17	.24	.02	.29
. 36	B	.07	.21	.21	.07	.12	.29
. 37	C	.12	.24	.31	.04	.07	.19
38	C	.34	.12	.26	.07	.14	.04
39	D	.14	.09	.07	.48	.09	.09

x = arithmetic question   no mark = algebra question $\overline{X} = 42.0$

. = trigonometry question   SD = 13.5

TABLE VIII

PILOT PRECALCULUS MATHEMATICS 1600 SAMPLE: ITEM DIFFICULTY AND ITEM DISCRIMINATION INDEX

Question No.	Correct Answer	Difficulty	Discrim. Index
x 1	E	.875	-.25
x 2	A	.875	-.25
x 3	B	.500	.00
4	C	.250	.50
5	B	.875	.25
6	A	.625	.75
7	B	.625	.75
x 8	B	.875	.25
9	C	.875	.25
10	E	.375	.75
11	D	.375	.00
12	C	.375	.00
13	B	.625	.25
14	E	.375	.25
15	B	.250	.00
. 16	D	.250	.25
. 17	B	.125	.25
. 18	E	.375	.00
19	B	.250	.25
20	A	.125	.25
x 21	A	.250	.00
. 22	A	.000	.00
. 23	E	.250	.25
. 24	E	.250	.50
. 25	B	.125	.25
26	C	.125	-.25
27	C	.500	.75
28	B	.250	.25
. 29	B	.375	.25
. 30	C	.500	.50
. 31	B	.125	-.25
32	A	.375	.25
33	C	.000	.00
. 34	C	.000	.25
. 35	C	.000	.25
. 36	B	.250	.00
. 37	C	.125	.25
38	C	.125	.50
39	D	.125	.25

x = arithmetic question   no mark = algebra question $\overline{X}$ = 34.5
. = trigonometry question   SD = 10.9

TABLE IX

PILOT PRECALCULUS MATHEMATICS 1600 SAMPLE
EFFECTIVENESS OF DISTRACTORS

Question No.	Correct Answer	Proportions A	B	C	D	E	Omit
x 1	E	.12	.00	.00	.00	.87	.00
x 2	A	.87	.00	.12	.00	.00	.00
x 3	B	.00	.50	.12	.00	.37	.00
4	C	.37	.00	.25	.12	.25	.00
5	B	.12	.87	.00	.00	.00	.00
6	A	.62	.00	.37	.00	.00	.00
7	B	.25	.62	.12	.00	.00	.00
x 8	B	.12	.87	.00	.00	.00	.00
9	C	.00	.12	.87	.00	.00	.00
10	E	.00	.12	.25	.25	.37	.00
11	D	.25	.12	.12	.37	.00	.12
12	C	.00	.37	.37	.00	.12	.12
13	B	.37	.62	.00	.00	.00	.00
14	E	.00	.37	.25	.00	.37	.00
15	B	.00	.25	.00	.50	.25	.00
. 16	D	.25	.25	.12	.25	.00	.12
. 17	B	.00	.12	.12	.37	.12	.25
. 18	E	.12	.00	.37	.00	.37	.12
19	B	.25	.25	.37	.00	.00	.12
20	A	.12	.00	.12	.50	.00	.25
x 21	A	.25	.25	.25	.00	.00	.25
. 22	A	.00	.62	.37	.00	.00	.00
. 23	E	.00	.37	.12	.12	.25	.12
. 24	E	.25	.37	.00	.12	.25	.00
. 25	B	.12	.12	.50	.00	.00	.25
26	C	.12	.50	.12	.00	.25	.00
27	C	.12	.25	.50	.00	.00	.12
28	B	.12	.25	.12	.37	.00	.12
. 29	B	.12	.37	.37	.00	.12	.00
. 30	C	.12	.12	.50	.00	.00	.25
. 31	B	.62	.12	.00	.00	.00	.25
32	A	.37	.00	.00	.37	.00	.25
33	C	.00	.00	.00	.25	.25	.50
. 34	C	.12	.00	.00	.00	.50	.37
. 35	C	.00	.12	.00	.37	.12	.37
. 36	B	.00	.25	.12	.00	.12	.50
. 37	C	.00	.37	.12	.00	.00	.50
38	C	.00	.00	.12	.37	.12	.37
39	D	.12	.12	.12	.12	.00	.50

x = arithmetic question no mark = algebra question $\overline{X}$ = 34.5
. = trigonometry question SD = 10.9

TABLE X

PILOT CALCULUS 1810 SAMPLE: ITEM DIFFICULTY AND ITEM DISCRIMINATION INDEX

Question No.	Correct Answer	Difficulty	Discrim. Index
x 1	E	.959	-.07
x 2	A	.839	.00
x 3	B	.839	.30
4	C	.719	.00
5	B	.799	.23
6	A	.879	.23
7	B	.839	.15
x 8	B	.959	.07
9	C	.919	.15
10	E	.759	.15
11	D	.479	.30
12	C	.439	.07
13	B	.879	.07
14	E	.439	-.07
15	B	.359	-.30
. 16	D	.359	.00
. 17	B	.279	-.38
. 18	E	.199	.15
19	B	.559	.07
20	A	.239	-.07
x 21	A	.799	.15
. 22	A	.359	-.53
. 23	E	.159	-.15
. 24	E	.159	-.07
. 25	B	.279	-.07
26	C	.039	-.38
27	C	.439	-.15
28	B	.439	.07
. 29	B	.279	-.15
. 30	C	.359	-.15
. 31	B	.000	-.30
32	A	.839	.23
33	C	.399	-.15
. 34	C	.159	-.30
. 35	C	.159	-.15
. 36	B	.319	-.07
. 37	C	.319	-.53
38	C	.319	.00
39	D	.239	.07

x = arithmetic question   no mark = algebra question $\bar{X}$ = 47.7
. = trigonometry question   SD = 9.7

TABLE XI

PILOT CALCULUS 1810 SAMPLE: EFFECTIVENESS OF DISTRACTORS

Question No.	Correct Answer	Proportions A	B	C	D	E	Omit
x 1	E	.00	.00	.04	.00	.96	.00
x 2	A	.84	.08	.08	.00	.00	.00
x 3	B	.00	.84	.00	.04	.12	.00
4	C	.04	.08	.72	.04	.00	.12
5	B	.16	.80	.04	.00	.00	.00
6	A	.88	.04	.08	.00	.00	.00
7	B	.04	.84	.12	.00	.00	.00
x 8	B	.04	.96	.00	.00	.00	.00
9	C	.00	.04	.92	.04	.00	.00
10	E	.00	.04	.16	.04	.76	.00
11	D	.28	.00	.20	.48	.00	.04
12	C	.04	.28	.44	.04	.00	.20
13	B	.04	.88	.00	.04	.04	.00
14	E	.20	.04	.24	.04	.44	.04
15	B	.20	.36	.12	.24	.08	.00
. 16	D	.28	.04	.20	.36	.04	.08
. 17	B	.04	.28	.44	.12	.08	.04
. 18	E	.12	.04	.44	.12	.20	.08
19	B	.12	.56	.12	.08	.12	.00
20	A	.24	.20	.16	.24	.00	.16
x 21	A	.80	.00	.04	.04	.00	.12
. 22	A	.36	.12	.28	.20	.00	.04
. 23	E	.08	.08	.32	.24	.16	.12
. 24	E	.16	.32	.12	.16	.16	.08
. 25	B	.04	.28	.24	.24	.08	.12
26	C	.12	.56	.04	.20	.04	.04
27	C	.20	.28	.44	.00	.00	.08
28	B	.12	.44	.04	.12	.24	.04
. 29	B	.20	.28	.08	.16	.20	.08
. 30	C	.16	.08	.36	.04	.28	.08
. 31	B	.36	.00	.04	.44	.04	.12
32	A	.84	.04	.00	.08	.00	.04
33	C	.20	.00	.40	.20	.08	.12
. 34	C	.08	.16	.16	.08	.40	.12
. 35	C	.12	.08	.16	.48	.04	.12
. 36	B	.20	.32	.12	.04	.16	.16
. 37	C	.00	.28	.32	.16	.08	.16
38	C	.24	.16	.32	.08	.08	.12
39	D	.24	.04	.16	.24	.16	.16

x = arithmetic question   no mark = algebra question $\overline{X} = 47.7$
. = trigonometry question   SD = 9.7

TABLE XII

ITEMS COMPOSING EACH PART SCORE OF THE UTM MATHEMATICS PLACEMENT EXAMINATION

Part Score	Item Numbers	% of Total
Arithmetic	1, 2, 3, 8, 21, 40	15
Algebra	4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 19, 20, 26, 27, 28, 32, 33, 38, 39	50
Trigonometry	16, 17, 18, 22, 23, 24, 25, 29, 30, 31, 34, 35, 36, 37	35
TOTAL		100

TABLE XIII

ITEM CONTENT CATEGORIES

Part
Arithmetic
Addition of fractions
Division of fractions
Signed numbers
Percentage
Ratio
Algebra
Algebraic substitution
Solutions of linear and quadratic equations
Simplification and factoring of algebraic expressions
Graphs of linear equations
Solution of simultaneous linear equations in two unknowns
Exponents involving positive and negative integers
Solutions of exponential equations
Complex numbers
Functional notation
Radicals
Simplification of algebraic fractions
Slope of a line
Trigonometry
Definition of trigonometric functions
Solution of triangles
Identities
Inverse functions
Period of trigonometric functions
Solution of trigonometric equations

CHAPTER IV

EVALUATION OF THE INSTRUMENT

Since the UTM Mathematics Placement Examination is a measure of a generalized homogeneous trait, evidence of internal consistency should be reported. Estimates of internal consistency should be determined by the split-half method or methods of the Kuder-Richardson type. Both call for items of nearly equal difficulty and intercorrelation. The most accurate of the practical Kuder-Richardson formulas is formula number 20 (Appendix C), which was used to measure the reliability of the UTM Mathematics Placement Examination.

Content and predictive validity were deemed essential in evaluating the UTM Mathematics Placement Examination. Content validity is a nonstatistical type that is associated with achievement examinations. When a test adequately covers both the content and the objectives of a course, it has content validity. The adequate job of sampling items and the experience of the test constructor is enough to assure that this placement examination has content validity. Predictive validity is a very common type of validity which is primarily statistical. It is the correlation between a set of test scores and some external measure. The placement test total scores were correlated individually with the students' first quarter college mathematics grades. This correlation was accomplished using the point-biserial coefficient of correlation (Appendix C). The dichotomy was established by using the mathematics grade C. Those having grades C or above were in the high group, and those having grades less than C were in the lower group. Also, the placement examination total scores were correlated with the Mathematics ACT Entrance Examination Scores. This correlation was accomplished using the Pearson's product-moment coefficient of correlation (Appendix C). Thus, a multiple correlation coefficient (Appendix C) between the UTM Mathematics Placement Examination and a combination of the Mathematics ACT scores and the first quarter college mathematics grades was found.

The discriminant function (Appendix D) which is a multivariate technique was used to establish cutting scores for the writer's mathematics placement test. The discriminant function has three principal types of uses: (1) classification and diagnosis, (2) the study of the relation between populations and (3) a multivariate generalization of the t-test. Snedecor and Cochran (1967, p. 414) made the following observation about the development of the discriminant function.

> Historically, it is interesting that the discriminant function was developed independently by R. A. Fisher, whose primary interest was in classification, by P. C. Mahalanobis, in connection with a large study of the relations between Indian castes and tribes and by H. Hotelling, who produced the multivariate t-test.

The discriminant function was used to determine the useful part scores of the placement test on the AB or DF groups of each freshman mathematics course.

A test of the hypothesis that the discriminant function has no discriminating ability was provided by the F test (Appendix D) with the use of the F tables at the 0.01 significance level.

The UTM Mathematics Placement Examination was given to 432 incoming freshmen on September 10, 1973, and 376 on September 17, 1973, during freshman orientation. Call these Group I and Group II respectively. These students were placed in mathematics courses by means of the current procedure of enrollment using high school background, ACT scores, and students' major areas of interest as was discussed earlier. At the end of the fall quarter 1973 each student's social security number, name, mathematics placement part scores, course taken, and grade received were punched on an IBM card. The reliability and validity coefficients discussed earlier were computed using Groups I and II. The 1130 IBM Computer was utilized in analyzing all data.

Discriminant analysis was applied to the data obtained from Groups I and II to establish cutting scores for each freshman mathematics course. In September, 1974, 800 students were given the same 40 question Mathematics Placement Test at UTM. Call this Group III. Students in Group III were placed in freshman mathematics courses in the fall quarter of 1974 using the cutting scores established by Groups I and II. Then the real adequacy of the discriminant function was tested using the previously discussed F test. The results are given in the next chapter.

CHAPTER V

THE RESULTS

The previous chapters have been concerned with the backgound of the institution and the students; the problem and previous research; the preparation of the UTM Mathematics Placement Examination; and the evaluation of the instrument. In this chapter the writer presents the results of the item analysis, the reliability coefficients, the validity coefficients, the discriminant analysis, the cutting scores, and the data received by the student advisors. The computer program to analyze test items with respect to difficulty, discrimination index, and effectiveness of the distractors was programed for a maximum of 200 students. Therefore two random subgroups, Subgroup I and Subgroup II, of 180 and 196 students were selected from the 808 fall quarter 1973 students to analyze the UTM Mathematics Placement Examination of forty questions. The mean and standard deviation of Subgroup I were 36.2 and 16.5. The mean and standard deviation of Subgroup II were 37.6 and 15.0. The results of the difficulty and discrimination index of each test item from Subgroup I and Subgroup II are listed in Tables XIV and XVI.

The difficulty of the six arithmetic questions of Subgroup I (Table XIV) ranged from .59 to .81, except item forty with .38. The difficulty of the six arithmetic items of Subgroup II (Table XVI) ranged from .65 to .85, except question forty with .42. The discrimination indexes of the six arithmetic questions of Subgroup I (Table XIV) ranged from .33 to .56. The discrimination indexes of the six arithmetic questions of Subgroup II (Table XVI) ranged from .31 to .51, except item 8 which was .22. However, item 8 in Subgroup I had a discrimination index of .34. The difficulty of the twenty algebra questions of Subgroup I (Table XIV) ranged from .30 to .74, except items 26, 32, 28, 38, and 39 with .18, .21, .21, .14, and .19 respectively. The algebra items of Subgroup II (Table XVI) had difficulty ranging from .32 to .83, except items 28, 33, and 39 with .18, .24, and .30 respectively. The discrimination index of the twenty algebra items of Subgroup I (Table XIV) ranged from .31 to .65, except items 26, 28, 33, 38, and 39 with .29, .25, .22, .13, and .29 respectively. The discrimination index of the twenty algebra questions of Subgroup II (Table XVI) ranged from .26 to .61, except items 9, 19, and 38 with .19, .20, and .18 respectively. The difficulty of the fourteen trigonometry items of Subgroup I (Table XIV) ranged from .14 to .29. The same items of Subgroup II (Table XVI) ranged from .12 to .24, except item 31 with .10. However, the difficulty of item 31 of Subgroup I was .16. The discrimination indexes of the fourteen trigonometry questions of Subgroup I (Table XIV) ranged from .24 to .43, except items 30, 31, 34, 35, and 36 with .02, .00, .08, .18, and .14 respectively. However, in Subgroup II (Table XVI) the trigonometry questions 30, 31, 34, 35, and 36 had discrimination indexes of .16, .13, .18, .03, and .15 respectively.

TABLE XIV

SAMPLE SUBGROUP I OF 180 STUDENTS: ITEM DIFFICULTY AND ITEM DISCRIMINATION INDEX

Question No.	Correct Answer	Difficulty	Discrim. Index
x 1	E	.788	.39
x 2	A	.666	.44
x 3	B	.588	.56
4	C	.688	.45
5	B	.583	.59
6	A	.583	.65
7	B	.616	.51
x 8	B	.805	.34
9	C	.744	.38
10	E	.338	.62
11	D	.500	.38
12	C	.449	.39
13	B	.472	.64
14	E	.322	.68
15	B	.299	.61
. 16	D	.183	.25
. 17	B	.288	.32
. 18	E	.183	.43
19	B	.355	.28
20	A	.466	.56
x 21	A	.622	.41
. 22	A	.205	.24
. 23	E	.222	.25
. 24	E	.177	.36
. 25	B	.161	.26
26	C	.177	.29
27	C	.305	.43
28	B	.205	.25
. 29	B	.211	.31
. 30	C	.155	.02
. 31	B	.155	.00
32	A	.449	.52
33	C	.205	.22
. 34	C	.138	.08
. 35	C	.199	.18
. 36	B	.199	.14
. 37	C	.144	.32
38	C	.138	.13
39	D	.194	.29
x 40	A	.383	.33

x = arithmetic question . = trigonometry question | no mark = algebra question | $\overline{X}$ = 36.2 SD = 16.5

TABLE XV

SAMPLE SUBGROUP I OF 180 STUDENTS
EFFECTIVENESS OF DISTRACTORS

Question No.	Correct Answer	Proportions A	B	C	D	E	Omit
x 1	E	.14	.00	.02	.03	.78	.00
x 2	A	.66	.19	.05	.02	.04	.01
x 3	B	.05	.58	.15	.09	.11	.00
4	C	.05	.16	.68	.02	.05	.00
5	B	.28	.58	.03	.02	.06	.00
6	A	.58	.06	.24	.09	.01	.00
7	B	.12	.61	.16	.06	.03	.00
x 8	B	.12	.80	.03	.03	.00	.00
9	C	.03	.05	.74	.11	.05	.00
10	E	.07	.11	.24	.18	.33	.03
11	D	.16	.05	.25	.50	.01	.01
12	C	.13	.17	.45	.10	.06	.07
13	B	.20	.47	.07	.16	.06	.02
14	E	.06	.15	.42	.03	.32	.00
15	B	.19	.30	.11	.23	.15	.00
. 16	D	.26	.10	.33	.18	.03	.08
. 17	B	.10	.28	.23	.21	.07	.08
. 18	E	.11	.10	.22	.29	.18	.08
19	B	.13	.35	.20	.12	.11	.07
20	A	.46	.11	.16	.07	.15	.02
x 21	A	.62	.11	.10	.03	.10	.01
. 22	A	.20	.17	.26	.14	.11	.09
. 23	E	.09	.18	.17	.18	.22	.13
. 24	E	.18	.08	.18	.25	.17	.10
. 25	B	.05	.16	.30	.21	.10	.16
26	C	.18	.32	.17	.08	.17	.05
27	C	.17	.13	.30	.12	.16	.08
28	B	.33	.20	.07	.18	.13	.06
. 29	B	.18	.21	.16	.13	.12	.16
. 30	C	.16	.17	.15	.12	.18	.18
. 31	B	.32	.15	.10	.14	.07	.18
32	A	.45	.09	.08	.22	.06	.07
33	C	.10	.06	.20	.19	.31	.11
. 34	C	.12	.13	.13	.07	.30	.22
. 35	C	.12	.18	.20	.15	.10	.23
. 36	B	.16	.20	.11	.12	.14	.26
. 37	C	.18	.26	.14	.10	.04	.26
38	C	.15	.14	.13	.16	.11	.28
39	D	.20	.16	.16	.19	.06	.21
x 40	A	.38	.08	.15	.07	.07	.23

x = arithmetic question no mark = algebra question $\overline{X}$ = 36.2
. = trigonometry question SD = 16.5

TABLE XVI

SAMPLE SUBGROUP II OF 196 STUDENTS: ITEM DIFFICULTY AND ITEM DISCRIMINATION INDEX

Question No.	Correct Answer	Difficulty	Discrim. Index
x 1	E	.816	.31
x 2	A	.653	.51
x 3	B	.658	.47
4	C	.750	.33
5	B	.658	.41
6	A	.617	.46
7	B	.683	.44
x 8	B	.846	.22
9	C	.852	.19
10	E	.367	.54
11	D	.520	.37
12	C	.428	.27
13	B	.510	.53
14	E	.331	.59
15	B	.321	.54
. 16	D	.188	.28
. 17	B	.244	.25
. 18	E	.153	.30
19	B	.326	.20
20	A	.469	.61
x 21	A	.647	.45
. 22	A	.234	.29
. 23	E	.188	.28
. 24	E	.219	.33
. 25	B	.127	.22
26	C	.173	.26
27	C	.326	.45
28	B	.178	.38
. 29	B	.183	.33
. 30	C	.122	.16
. 31	B	.096	.13
32	A	.505	.46
33	C	.239	.26
. 34	C	.147	.18
. 35	C	.153	.03
. 36	B	.132	.15
. 37	C	.209	.25
38	C	.153	.18
39	D	.295	.32
x 40	A	.423	.33

x = arithmetic question   no mark = algebra question $\overline{X}$ = 37.6

. = trigonometry question   SD = 15.0

TABLE XVII

SAMPLE SUBGROUP II OF 196 STUDENTS
EFFECTIVENESS OF DISTRACTORS

Question No.	Correct Answer	Proportions A	B	C	D	E	Omit
x 1	E	.10	.00	.01	.06	.81	.00
x 2	A	.65	.25	.05	.01	.01	.01
x 3	B	.05	.65	.12	.03	.13	.00
4	C	.05	.07	.75	.04	.05	.02
5	B	.26	.65	.03	.01	.02	.01
6	A	.61	.03	.28	.04	.00	.01
7	B	.08	.68	.13	.03	.03	.03
x 8	B	.09	.84	.02	.01	.02	.00
9	C	.02	.03	.85	.07	.02	.00
10	E	.10	.14	.17	.11	.36	.09
11	D	.13	.04	.21	.52	.04	.03
12	C	.08	.14	.42	.16	.08	.09
13	B	.18	.51	.10	.13	.06	.01
14	E	.08	.13	.40	.02	.33	.02
15	B	.17	.32	.13	.23	.10	.02
. 16	D	.23	.09	.34	.18	.01	.11
. 17	B	.07	.24	.22	.22	.10	.12
. 18	E	.15	.05	.22	.27	.15	.14
19	B	.15	.32	.21	.12	.09	.09
20	A	.46	.12	.10	.09	.15	.05
x 21	A	.64	.07	.07	.04	.12	.03
. 22	A	.23	.12	.18	.17	.12	.14
. 23	E	.09	.18	.22	.14	.18	.15
. 24	E	.13	.10	.16	.26	.21	.11
. 25	B	.05	.12	.23	.27	.07	.22
26	C	.13	.41	.17	.10	.12	.05
27	C	.17	.17	.32	.05	.19	.07
28	B	.30	.17	.09	.17	.17	.06
. 29	B	.17	.18	.12	.19	.12	.18
. 30	C	.22	.10	.12	.15	.19	.20
. 31	B	.40	.09	.14	.12	.03	.19
32	A	.50	.11	.05	.24	.03	.04
33	C	.10	.07	.23	.20	.27	.09
. 34	C	.10	.16	.14	.09	.25	.23
. 35	C	.11	.17	.15	.24	.06	.23
. 36	B	.17	.13	.15	.10	.14	.28
. 37	C	.10	.25	.20	.10	.05	.27
38	C	.27	.11	.15	.14	.08	.22
39	D	.20	.07	.17	.29	.06	.18
x 40	A	.42	.11	.10	.08	.06	.21

x = arithmetic question   no mark = algebra question $\overline{X}$ = 37.6
. = trigonometry question   SD = 15.0

TABLE XVIII

RELIABILITY COEFFICIENTS FOR PART SCORES OF THE UTM MATHEMATICS PLACEMENT EXAMINATION

Part Score	Mean (Raw Scores)	SD	No. of Items	KR20
Arith.	3.97	1.57	6	.59
Alg.	8.52	3.96	20	.77
Trig.	2.54	1.97	14	.50
Arith. and Alg.	12.49	5.14	26	.82
Alg. and Trig.	11.03	4.97	34	.77
TOTAL	15.01	6.07	40	.81

There are 808 students in groups I and II.
KR20 is the Kuder-Richardson formula 20 reliability coefficient.

The diverse backgrounds of the students taking the UTM Mathematics Placement Examination require the examination to consist of a few extremely hard and extremely easy questions to assess the student's levels of mastery of important mathematical skills. The questions on the UTM Mathematics Placement Examination having great or little difficulty or low discrimination were of the above type and therefore retained.

The third type of information obtained from the item analysis was the effectiveness of the distractors. Analysis of the distractors revealed that only item one of Subgroup I (Table XV) had a distractor of .00 proportion, and only items one and six of Subgroup II (Table XVII) had a distractor of .00 proportion. Tables XV and XVII of Subgroup I and Subgroup II illustrate that the distractors of the other items were effective.

The reliability coefficients for Part Scores of the UTM Mathematics Placement Examination were computed using Kuder-Richardson formula 20 and the Computer Program I in Appendix F. The reliability coefficients of the part scores (Table XVIII) ranged from .50 to .82 with a total score coefficient of .81.

Predictive validity coefficients were obtained using the Pearson's Product-Moment Coefficient of Correlation, the point-biserial coefficient of correlation, and a multiple correlation coefficient. (See Computer Program II, Appendix F.) The Pearson's Product-Moment Coefficient of Correlation (Table XIX) for all students enrolled in a freshman mathematics course having a UTM Mathematics Placement Examination total score and a corresponding

Mathematics ACT Entrance Examination score was .74. The Pearson's Product-Moment Coefficients of Correlation between the UTM Mathematics Placement Examination and the Mathematics ACT Entrance Examination scores for each course (Table XIX) ranged from .55 to .66, except Core Mathematics 1001 with .35. The point-biserial coefficient of correlation (Table XX) for all students having a UTM Mathematics Placement Examination total score and a corresponding first quarter grade in a freshman mathematics course was .31. The point-biserial coefficients of correlation between the UTM Mathematics Placement Examination and the first quarter grade in each freshman mathematics course (Table XX) ranged from .27 to .55. Precalculus Mathematics had .27 and Calculus 1810 had .55. The point-biserial coefficients of correlation between the Mathematics ACT Entrance Examination scores and the first quarter grades for each course are listed in Table XXI. The point-biserial coefficient of correlation between the UTM Mathematics Placement Examination and the grades for each course was higher than the point-biserial coefficient of correlation between the Mathematics ACT Entrance Examination scores and the grades for each course, except College Algebra 1300 and Precalculus Mathematics 1600. The multiple correlation coefficients between the UTM Mathematics Placement Examination total scores and a combination of the first quarter college mathematics grades and the Mathematics ACT Entrance Examination scores are listed in Table XXII. The multiple correlation coefficients ranged from .55 to .75, except Core Mathematics 1001 with .44. The data of Tables XIX, XX, XXI, and XXII indicated that

TABLE XIX

PEARSON'S PRODUCT-MOMENT COEFFICIENT OF CORRELATION BETWEEN THE UTM MATHEMATICS PLACEMENT EXAMINATION TOTAL SCORE AND THE MATHEMATICS ACT ENTRANCE EXAMINATION SCORE

Course	N	XT	SDT	XMA	SDMA	r
1001	83	23.33	8.65	14.03	5.08	0.35
1002	23	27.17	9.64	15.91	5.14	0.66
1040	22	44.13	11.87	22.13	6.42	0.61
1110	264	38.81	12.91	21.07	4.90	0.65
1300	19	37.15	7.77	19.94	4.43	0.56
1600	44	43.40	11.06	23.88	4.01	0.55
1810	82	58.85	10.68	27.59	3.50	0.62
T_1	747	37.88	15.16	20.04	6.51	0.74

N = Number of students in each course with a UTM Mathematics Placement Examination total score and a corresponding Mathematics ACT Entrance Examination score.

XT = Mean of the UTM Mathematics Placement Examination total scores.

SDT = Standard deviation of the UTM Mathematics Placement Examination total scores.

XMA = Mean of the Mathematics ACT Entrance Examination scores.

SDMA = Standard deviation of the Mathematics ACT Entrance Examination scores.

r = Pearson's Product-Moment Coefficient of Correlation.

T_1 is defined as every student, whether or not he is enrolled in a mathematics course, having a UTM Mathematics Placement Examination total score and a corresponding Mathematics ACT Entrance Examination score.

TABLE XX

POINT-BISERIAL COEFFICIENT OF CORRELATION BETWEEN THE UTM MATHEMATICS PLACEMENT EXAMINATION TOTAL SCORE AND THE FIRST QUARTER COLLEGE MATHEMATICS GRADE

Course	NHG	XNHG	NLG	XNLG	r_{pb}
1001	57	24.21	15	17.60	0.30
1002	15	30.93	11	21.63	0.49
1040	15	48.60	7	36.42	0.51
1110	188	43.05	59	31.49	0.39
1300	12	39.33	7	32.42	0.36
1600	35	44.88	9	37.33	0.27
1810	64	61.95	17	47.47	0.55
T_2	386	43.20	125	31.93	0.31

NHG = Number of students having UTM Mathematics Placement Examination total score and a first quarter mathematics grade of C or above.

XNHG = Mean of the total scores on the UTM Mathematics Placement Examination of students having a first quarter mathematics grade of C or above.

NLG = Number of students having UTM Mathematics Placement Examination total score and a first quarter mathematics grade of D or F.

XNLG = Mean of the total scores on the UTM Mathematics Placement Examination of students having a first quarter mathematics grade of D or F.

r_{pb} = Point-biserial coefficient of correlation.

T_2 is defined as every student having a UTM Mathematics Placement Examination total score and a corresponding first quarter grade in a freshman mathematics course listed in the above table.

TABLE XXI

POINT-BISERIAL COEFFICIENT OF CORRELATION BETWEEN MATHEMATICS ACT ENTRANCE EXAMINATION SCORES AND THE FIRST QUARTER COLLEGE MATHEMATICS GRADE

Course	NHG	XNHG	NLG	XNLG	r_{pb}
1001	52	14.40	9	12.77	0.12
1002	14	17.21	9	13.88	0.31
1040	14	24.07	7	20.00	0.32
1110	178	22.68	55	18.54	0.37
1300	12	22.50	7	15.57	0.75
1600	34	24.85	9	20.44	0.44
1810	63	28.60	17	24.82	0.46
T_3	367	22.56	113	18.71	0.27

NHG = Number of students having a Mathematics ACT Entrance Examination score and a first quarter mathematics grade of C or above who took the UTM Mathematics Placement Examination.

XNHG = Mean of the Mathematics Entrance Examination ACT scores of the students having a first quarter mathematics grade of C or above who took the UTM Mathematics Placement Examination.

NLG = Number of students having a Mathematics ACT Entrance Examination score and a first quarter mathematics grade of D or F who took the UTM Mathematics Placement Examination.

XNLG = Mean of the Mathematics ACT Entrance Examination scores of the students having a first quarter mathematics grade of D or F who took the UTM Mathematics Placement Examination.

r_{pb} = Point-biserial coefficient of correlation.

T_3 is defined as every student who took the UTM Mathematics Placement Examination having a Mathematics ACT Entrance Examination score and a first quarter mathematics grade.

TABLE XXII

MULTIPLE CORRELATION COEFFICIENT BETWEEN THE UTM MATHEMATICS PLACEMENT EXAMINATION TOTAL SCORES AND A COMBINATION OF THE FIRST QUARTER COLLEGE MATHEMATICS GRADES AND THE MATHEMATICS ACT ENTRANCE EXAMINATION SCORES

Course	$r_{1.23}$
1001	0.44
1002	0.72
1040	0.69
1110	0.67
1300	0.57
1600	0.55
1810	0.69
All Courses	0.75

$r_{1.23}$ = Multiple correlation coefficient between the UTM Mathematics Placement Examination total scores and a combination of the first quarter mathematics grades and the Mathematics ACT Entrance Examination scores.

the UTM Mathematics Placement Examination has some value for predicting the performances of students in all the courses intended.

Discriminant analysis was applied to the data obtained from Groups I and II consisting of 808 incoming freshmen in the fall quarter of September, 1973. The UTM Mathematics Placement Examination had six variables and each of the seven freshman mathematics courses involved had a possible sixty-three discriminant functions to consider and analyze. However, based upon the writer's experience and judgment, not all sixty-three possible discriminant functions were considered. Twenty-six discriminant functions were analyzed for each of the following courses: Core Mathematics 1001, Core Mathematics 1002, General Mathematics 1110, and College Algebra 1300. Thirty-five discriminant functions were analyzed for each of the following courses: Trigonometry 1040, Precalculus Mathematics 1600, and Calculus 1810. The UTM Mathematics Placement Examination Scores of the AB and DF groups for each course were punched on IBM cards using Computer Program III, Appendix F. Using the appropriate AB and DF groups from each course the selected discriminant functions of each course were analyzed using the Computer Program IV, Appendix F. The output of the Computer Program IV listed for each combination of variables for each course the means on the original variables, the covariance matrix, the inverse of the covariance matrix, the discriminant function coefficients, D-square, the F ratio, the group means on the discriminant function, the frequency distribution of the discriminant function and the decile frequencies and proportions of the AB and DF groups.

After careful analysis the writer selected the discriminant functions' coefficients and cutting scores listed in Table XXIII for each course. The means on the original variables and group means on the discriminant function were also listed in Table XXIII. For the discriminant function of each course the sample sizes of the AB and DF groups of fall, 1973, the degrees of freedom for Between Samples, the degrees of freedom for Within Samples, the difference between means squared of the discriminant function, the F ratios, and the level of significance of the F ratios are listed in Table XXIV. The discriminant function for Core Mathematics 1001 was derived from 40 students in the AB group and 15 students in the DF group using the variables arithmetic, algebra, and arithmetic-algebra. With the aid of the AB and DF group means on the discriminant function of 5.01 and 3.25 and the frequency distribution of the discriminant function scores, the cutting score of 5.02 or below was selected for Core Mathematics 1001. With an AB group of 7 students, a DF group of 11 students and twenty-six different combinations of the UTM Mathematics Placement Examination variables, no discrimination function was found for Core Mathematics 1002 with an F ratio significance level of at least .05. However, this was a very small sample size for the AB and DF groups of Core Mathematics 1002. But the Core Mathematics 1002 class in the fall of 1973 had a total of only 26 students. The discriminant function for the General Mathematics 1110 was derived from 135 students in the AB group and 59 students in the DF group using the variables arithmetic and algebra. No discriminant function with an F ratio

TABLE XXIII

FALL, 1973, GROUP I AND GROUP II: MEANS ON ORIGINAL VARIABLES, DISCRIMINANT FUNCTION COEFFICIENTS, GROUP MEANS ON DISCRIMINANT FUNCTION, AND CUTTING SCORES

Course		x_1	x_2	x_3	x_4	x_5	x_6	GXV_i	Cutting Score
1001	AB	47.87	26.12		31.150			5.01	$V_1 \leq 5.02$
	DF	27.80	19.66		21.46			3.25	
	V_1	- 0.118	- 0.491		0.754				
1002	AB	59.42	32.85		38.71				$V_1 > 5.02$
	DF	41.00	21.81		26.18				and
	V_1	- 0.118	- 0.491		0.754				$V_3 < 10.3$
	V_3	0.108	0.112						
1040	AB		65.00	21.428	72.00	47.00	54.00	9.98	$V_2 \geq -6.5$
	DF		40.00	14.285	48.85	29.00	36.42	-11.92	and
	V_2		-14.656	-17.943	-14.271	27.36	20.16		$x_6 \geq 30$
1110	AB	82.76	55.25					15.19	$V_3 \geq 10.3$
	DF	57.89	35.67					10.29	
	V_3	0.108	0.112						
1600	AB	80.92	62.85	20.85	67.21	45.50	50.57	3.54	$V_4 \geq -1.82$
	DF	68.66	33.33	14.77	41.22	25.55	31.77	- 7.40	and
	V_4	- 3.309	- 9.194	- 0.112	11.905	- 1.609	2.464		$x_6 \geq 32$

TABLE XXIII (Continued)

Course		x_1	x_2	x_3	x_4	x_5	x_6	GXV_i	Cutting Score
1810	AB		73.83	32.94	78.19	57.01		- 1.87	$V_5 \geq -3.53$
	DF		54.70	22.35	61.35	41.17		- 3.61	and
	V_5		- 2.693	- 2.060	- 0.307	5.067			$x_6 \geq 42$

x_1 = arithmetic variable on UTM Mathematics Placement Examination

x_2 = algebra variable

x_3 = trigonometry variable

x_4 = arithmetic and algebra variable

x_5 = algebra and trigonometry variable

x_6 = total score variable

GXV_i = group means on the discriminant function

V_1 = discriminant function Core Mathematics 1001 ($V_1 = -.118x_1 - 0.491x_2 + 0.754x_4$)

V_2 = discriminant function for Trigonometry 1040 ($V_2 = -14.656x_2 - 17.943x_3 - 14.271x_4 + 27.36x_5 + 20.16x_6$)

V_3, V_4, and V_5 = discriminant functions for General Mathematics 1110, Precalculus Mathematics 1600, and Calculus 1810 respectively.

TABLE XXIV

FALL, 1973, GROUP I AND GROUP II USED TO DERIVE DISCRIMINANT FUNCTIONS: SAMPLE SIZES, DEGREES OF FREEDOM, D SQUARE, AND F TEST

Disc. F	n_1	n_2	p	df_1	df_2	D Square	F Test	Critical F (Level)
V_1(1001)	40	15	3	3	51	1.76	6.17	.01
V_2(1040)	7	7	5	5	8	21.90	10.22	.01
V_3(1110)	135	59	2	2	191	4.90	100.09	.01
V_4(1600)	14	9	6	6	16	10.95	7.62	.01
V_5(1810)	56	17	4	4	69	1.73	5.40	.01

Disc. F = discriminant function

V_i(C), $1 \leq i \leq 5$, = discriminant function of course C.

n_1 = number of students in AB group

n_2 = number of students in DF group

p = number of variables in the discriminant function

df_1 = degrees of freedom for Between Samples

df_2 = degrees of freedom for Within Samples

D Square = difference of group means on the discriminant function squared

having a significance level of at least .05 was found for College Algebra 1300. However, the College Algebra 1300 class had a total of 19 students in the fall of 1973, with an AB group of 3 and a DF group of 7. These sample sizes were too small.

Discriminant functions were found for Trigonometry 1040, Precalculus Mathematics 1600, and Calculus 1810 with AB groups 7, 14, and 56, and DF groups 7, 9, and 17 respectively. The cutting scores obtained for Trigonometry 1040, Precalculus Mathematics 1600, and Calculus 1810 were established using the AB and DF group means of the discriminant function together with a frequency distribution of the discriminant function scores. These cutting scores were -6.5 or above, -1.82 or above, and -3.53 or above for Trigonometry 1040, Precalculus Mathematics 1600, and Calculus 1810 respectively. Since extremely low raw scores affect negative cutting scores, a lower bound was attached to the cutting score. This lower bound was a UTM Mathematics Placement total score of at least 30, 32, and 42 for Trigonometry 1040, Precalculus Mathematics 1600, and Calculus 1810 respectively. These lower bounds were derived by the writer from observing scoring patterns on the samples being considered.

In September, 1974, 800 students called Group III were given the same 40 question UTM Mathematics Placement Examination and placed in the appropriate mathematics courses using the derived cutting scores and Computer Program VI, Appendix F. Define V_1, V_2, V_3, V_4, and V_5 as the discriminant functions of Core Mathematics 1001, Trigonometry 1040, General Mathematics 1110, Precalculus Mathematics 1600, and Calculus 1810 respectively. Define x_6 as the total score on the UTM Mathematics Placement Examination. If a student's scores on the UTM Mathematics Placement Examination satisfied $V_5 = -3.53$ or above and $x_6 = 42$ or above, he was eligible to be placed in any of the freshman mathematics courses being considered. If a student did not satisfy the criteria for Calculus 1810 above, his UTM Mathematics Placement Examination scores were checked using the Precalculus Mathematics 1600 criteria, $V_4 = -1.82$ or above and $x_6 = 32$ or above. If the student's scores satisfied these cutting scores, then he was eligible to be placed in any UTM freshman mathematics course numbered 1600 or lower. If the student's scores did not satisfy the Precalculus Mathematics 1600 criteria above, his UTM Mathematics Placement scores were checked using the Trigonometry 1040 cutting scores, $V_2 = -6.5$ or above and $x_6 = 30$ or above. If the student's UTM Mathematics Placement Examination scores satisfied these cutting scores for Trigonometry 1040, then he was eligible to be placed in Trigonometry 1040, General Mathematics 1110, the Core Mathematics 1002, or Core Mathematics 1001. If the student's scores did not satisfy the above criteria for Trigonometry 1040, his UTM Mathematics Placement scores were compared with the General Mathematics 1110 cutting scores $V_3 = 10.3$ or above. If the student's scores satisfied the cutting scores for General Mathematics 1110 he was eligible to be placed in General Mathematics 1110, Core Mathematics 1002, or Core Mathematics 1001. If the student's scores did not satisfy the criteria for General Mathematics 1110, his mathematics placement scores were checked using the cutting scores of Core Mathematics 1001, $V_1 = 5.02$ or lower. If the student's scores satisfied the Core Mathematics 1001, he was eligible to be placed in Core Mathematics 1001. If not, he was eligible to enroll in Core Mathematics 1002.

The UTM Mathematics Placement Examination results were used only as an aid in helping the adviser to place the student in the appropriate freshman mathematics course. The final decision as to what freshman mathematics course (if any) a student at UTM should enroll in was the responsibility of the student and his adviser. The mathematics placement information received by each student's adviser can be found in Appendix E.

At the end of the fall quarter, 1974, an IBM card for each student of Group III enrolled in a freshman mathematics course was punched with the student's social security number, name, mathematics placement part scores, course taken, and grade received. The AB and DF groups from each Group III freshman mathematics course were used to test the real adequacy of each discriminant function in Table XXIII by means of the F test. The Computer Program V was used to compute not only the adequacy of each of the discriminant functions but also the means of the AB, ABC, DF, and total groups of the UTM Placement Examination variables pertinent to each function. These results are listed in Tables XXV and XXVI. All the discriminant functions used in placing Group III students had an F test ratio that was significant at the one per cent level (Table XXVI). Hence each discriminator did have some ability to discriminate between the AB and DF groups of each course. However, the degrees of freedom for the Within Samples of Trigonometry 1040 and Precalculus

Mathematics 1600 were 8 and 17 respectively. These degrees of freedom were small. As a point of interest, the writer also used the ABC and DF groups from each Group III freshman mathematics course to check the real adequacy of each discriminant using the F test. These results were listed in Table XXVII. Each discriminant function had an F ratio that was significant at the one per cent level (Table XXVII). Hence, each discriminator did have some ability to discriminate between the ABC and DF groups of each course. The Within Samples of Trigonometry 1040 and Precalculus Mathematics 1600 were small with 12 and 26 degrees of freedom respectively.

The UTM Placement Examination did help in placing the students in the appropriate freshman mathematics courses. Further evidence was listed in Table XXVIII. Failure in a course was defined to mean a student's receiving a grade of D or F in a course. Those students of Group III placed by the UTM Placement Examination had a lower failure rate than those students of Groups I and II placed without the placement examination (Table XXVIII). The failure rate decreased in Core Mathematics 1002 from 42 per cent to 28 per cent, in Trigonometry 1040 from 32 per cent to 11 per cent, in General Mathematics 1110 from 24 per cent to 17 per cent, in Precalculus Mathematics 1600 from 20 per cent to 12 per cent, and Calculus 1810 from 21 per cent to 4 per cent. The failure rate of College Algebra 1300 was not determined since the sample sizes were too small to derive a discriminant function for placement purposes. The failure rate and significance of the F ratio of the discriminant function for Core Mathematics 1001 was not determined, because Core Mathematics 1001 was the course appropriate for those students who did not qualify to be placed in any other freshman mathematics course. The results of Chapter V indicated that the UTM Mathematics Placement Examination was successful in placing students in Core Mathematics 1002, General Mathematics 1110, Trigonometry 1040, Precalculus Mathematics 1600, and Calculus 1810 at the University of Tennessee at Martin.

TABLE XXV

FALL, 1974, GROUP III: MEANS ON ORIGINAL VARIABLES USED IN THE DISCRIMINANT FUNCTION OF AB, ABC, DF, AND TOTAL GROUPS FOR EACH COURSE

Course		N	x_1	x_2	x_3	x_4	x_5	x_6
1001	AB	46	45.30	19.23	6.71			
	ABC	74	40.32	19.79	8.08			
	DF	34	22.61	20.29	10.79			
	TG	108	34.75	19.95	8.93			
	SD		19.5	8.29	8.84			
1002	AB	15	55.66	26.00				
	ABC	23	47.86	26.52				
	DF	9	44.44	23.88				
	TG	32	46.90	25.78				
	SD		14.79	9.6				
1040	AB	11		68.63	20.00	74.18	48.63	55.00
	ABC	16		60.00	19.93	67.31	43.50	50.62
	DF	2		42.50	3.50	50.00	26.50	33.50
	TG	18		58.05	18.11	65.38	41.61	48.72
	SDT			18.49	9.72	15.00	12.31	11.02
1110	AB	166	84.34	53.16				
	ABC	224	81.92	49.77				
	DF	46	65.87	32.71				
	TG	270	79.19	46.87				
	SDT		18.63	16.25				
1600	AB	20	77.50	60.75	19.90	64.85	43.85	48.70
	ABC	29	78.13	58.96	20.06	63.62	42.86	47.93
	DF	4	62.50	50.00	7.00	53.00	32.00	36.75
	TG	33	76.24	57.87	18.48	62.33	41.54	46.57
	SD		14.79	10.66	11.65	10.22	9.44	8.87

TABLE XXV (Continued)

Course		N	x_1	x_2	x_3	x_4	x_5	x_6
1810	AB	41		77.92	37.80	81.48	61.48	
	ABC	49		75.91	35.85	79.65	59.48	
	DF	2		47.50	36.00	54.00	42.50	
	TG	51		74.80	35.86	78.64	58.82	
	SD			13.93	20.43	11.88	14.70	

N = number of students

x_1 = arithmetic variable

x_2 = algebra variable

x_3 = trigonometry variable

x_4 = arithmetic and algebra variable

x_5 = algebra and trigonometry variable

x_6 = total score variable

TG = mean of the ABC and DF groups

SD = standard deviation of ABC and DF groups

TABLE XXVI

FALL, 1974, AB AND DF GROUPS OF GROUP III USED TO TEST THE ADEQUACY OF THE DISCRIMINANT FUNCTIONS: CUTTING SCORES, SAMPLE SIZES, DEGREES OF FREEDOM, D SQUARE, AND F TEST

Disc. F	Cutting Scores	n_1	n_2	p	df_1	df_2	D Square	F Test	Critical F (level)
$V_3(1002)$	$<$ 10.3	15	9	2	2	21	2.09	76.04	.01
$V_2(1040)$	≥ -6.5 and $x_6 \geq 30$	11	2	5	5	8	222.01	20.86	.01
$V_3(1110)$	≥ 10.3	166	46	2	2	209	18.34	161113.9	.01
$V_4(1600)$	≥ -1.82 and $x_6 \geq 32$	20	4	6	6	17	2.36	13.06	.01
$V_5(1810)$	≥ -3.53 and $x_6 \geq 42$	41	2	4	4	38	4.47	20.09	.01

Disc. F = discriminant function

$V_i(C)$, $2 \leq i \leq 5$, = discriminant function of course C

n_1 = number of students in AB group

TABLE XXVI (Continued)

n_2 = number of students in DF group

p = number of variables in the discriminant function

df_1 = degrees of freedom for Between Samples

df_2 = degrees of freedom for Within Samples

D Square = difference of group means on the discriminant function squared

TABLE XXVII

FALL, 1974, ABC AND DF GROUPS OF GROUP III USED TO TEST THE ADEQUACY OF THE DISCRIMINANT FUNCTIONS: CUTTING SCORES, SAMPLE SIZES, DEGREES OF FREEDOM, D SQUARE, AND F TEST

Disc. F	Cutting Scores	n_1	n_2	p	df_1	df_2	D Square	F Test	Critical F (level)
$V_3(1002)$	< 10.3	23	9	2	2	29	0.441	57.83	.01
$V_2(1040)$	≥ -6.5 and $x_6 \geq 30$	16	2	5	5	12	141.44	28.54	.01
$V_3(1110)$	≥ 10.3	224	46	2	2	267	13.26	18479.2	.01
$V_4(1600)$	≥ -1.82 and $x_6 \geq 32$	29	4	6	6	26	0.763	11.35	.01
$V_5(1810)$	≥ -3.53 and $x_6 \geq 42$	49	2	5	5	46	3.902	22.71	.01

Disc. F = discriminant function

$V_i(C)$, $2 \leq i \leq 5$, = discriminant function of course C.

n_1 = number of students in ABC group

TABLE XXVII (Continued)

n_2 = number of students in DF group

p = number of variables in the discriminant function

df_1 = degrees of freedom for Between Samples

df_2 = degrees of freedom for Within Samples

D Square = difference of group means on the discriminant function squared

TABLE XXVIII

FALL, 1973 AND 1974, FAILURE RATE COMPARISON

	Fall, 1973				Fall, 1974			
Course	ABC	DF	T	% of DF's	ABC	DF	T	% of DF's
1002	15	11	26	42.3	23	9	32	28.12
1040	15	7	22	31.81	16	2	18	11.11
1110	188	59	247	23.88	224	46	270	17.03
1600	35	9	44	20.45	29	4	33	12.12
1810	64	17	81	20.98	49	2	51	3.92

T = total number of students in each course

Failure rate was defined as a student's receiving a grade of D or F.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The University of Tennessee at Martin had a very high failure and drop out rate for the heterogeneous student body enrolled in its freshman mathematics courses. The UTM mathematics faculty believed that placement procedures were the chief causes of the high drop out and failure rates. Therefore, a placement examination was designed especially to identify each of the following: 1) students needing remedial mathematics work, 2) students not adequately skilled in high school algebra and requiring training in intermediate algebra prior to more advanced work, 3) students sufficiently informed in intermediate algebra to be placed immediately in a college algebra course, 4) students proficient in algebra but deficient in trigonometry, 5) students needing a review of algebra and trigonometry, and 6) students demonstrating sufficient ability in college algebra and trigonometry to warrant their admission to a course in analytic geometry and calculus.

The forty-five minute UTM Mathematics Placement Examination consisted of forty items. All questions were multiple choice with five alternatives. Scores were obtainable for arithmetic, algebra, trigonometry, arithmetic-algebra, algebra-trigonometry, and total. Subject area items were distributed throughout the test with the items arranged in increasing difficulty. Students placed their answers on IBM sheets. These sheets were then graded on the IBM 1230 Optical Scanner.

Each test item was analyzed with respect to its difficulty, discrimination index, and distractors. A question with one of the following conditions was rewritten: 1) difficulty near zero or 2) discrimination index near zero or negative. Kuder-Richardson formula number 20 was used to measure the reliability of the UTM Mathematics Placement Examination. The placement test total scores were correlated individually with the students' first quarter college mathematics grades. This correlation was accomplished using the point-biserial coefficient of correlation. Also, the placement examination total scores were correlated with the Mathematics ACT Entrance Examination scores. This correlation was accomplished using the Pearson's product-moment coefficient of correlation. Thus, a multiple correlation coefficient between the UTM Mathematics Examination and a combination of the Mathematics ACT Entrance Examination scores and the first quarter college mathematics grades was found. The point-biserial coefficients of correlation, the Pearson's product-moment coefficients of correlation and the multiple correlation coefficients indicated that the UTM Mathematics Placement Examination had some value for predicting the performances of the students in all the freshman mathematics courses intended.

The discriminant function, which is a multivariate technique, was used to establish cutting scores for the UTM Mathematics

Placement Examination. The discriminant function was used to determine the useful part scores of the placement test on the AB or DF groups of each freshman mathematics course. A test of the hypothesis that the discriminant function had no discriminating ability was provided by the F test with the use of the F tables at the 0.01 significance level. Cutting scores were obtained for Core Mathematics 1001 and 1002 (arithmetic and remedial algebra), General Mathematics 1110 (liberal arts mathematics), Trigonometry 1040, Precalculus Mathematics 1600 (trigonometry and algebra), and Calculus 1810. All the discriminant functions used in placing the students had an F test ratio that was significant at the one per cent level. Failure rate was defined as a student's receiving a grade of D or F in a course. The failure rate of the students placed by the UTM Mathematics Placement Examination was lower than the failure rate of the students placed without the placement examination. The UTM Mathematics Placement Examination was successful in placing students in freshman mathematics courses.

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APPENDIX A

COURSE DESCRIPTIONS

1001 Core Mathematics I (3) Signed numbers, fractions, decimals, percentage, ratio and proportion, algebraic manipulation of formulas, operations on polynomials, linear equations.

1002 Core Mathematics II (3) Operations on polynomials, linear equations, exponents and radicals, complex numbers, factoring, algebraic fractions, quadratic equations, fractional equations.

1040 Trigonometry (3) The trigonometric functions, use of trigonometric tables, solution of right triangle vectors, solution of oblique triangles, trigonometric identities and equations. 3 hrs. per week.

1110 General Mathematics (3) Elementary set theory, real number system, selected topics from geometry and algebra. Problems are of practical nature as applied to the student's interest. Prereq.: 2 yrs. high school algebra or 1 yr. high school algebra and 1 yr. geometry.

1300 Selected Topics in Algebra (3) Sets and numbers, algebraic properties of the real numbers, binomial theorem, complex numbers, polynomial equations, rational exponents, and radicals. (1300 and 1110 cannot both be taken for credit.)

1600 Precalculus Mathematics (5) A study of elementary functions, their graphs and applications, including polynomials, rational and algebraic functions, exponential, logarithmic and trigonometric functions. Prereq.: 2 yrs. high school algebra and 1 yr. high school geometry. Credit not allowed for both Mathematics 1600 and 1040 or 1300.

1810-20-30 Analytic Geometry and Calculus of a Single Variable (4, 4, 4) Functions, graphs, mathematical induction, inequalities, limits, continuity, derivatives. Applications of derivatives, conics, integration and its applications. Inverse functions, logarithmic, exponential, and trigonometric functions, integration techniques, polar coordinates. Must be taken in sequence. Prereq.: 2 yrs. high school algebra and one semester of trigonometry or equivalent.

APPENDIX B

THE TEST

Test Booklet No. ____________

The University of Tennessee at Martin

Mathematics Placement Examination

in

Intermediate Algebra and Trigonometry

Do not open the booklet

until instructed to do so.

General Directions

This is a 45 minute test. Do not spend too much time on any one question. If a question seems to be too difficult, make the most careful guess you can, rather than waste time over it. Do not worry if you do not finish the test. Your score is the number of correct answers you mark.

Use scratch paper to work problems. Do not make any marks in your test booklet.

<u>Mark all answers on the separate answer sheet</u>. Make your answer marks heavy and black. Mark only one answer for each question. If you make a mistake or wish to change an answer, be sure to erase your first choice completely.

UTM Mathematics Placement Test

1. $\frac{3}{4} + \frac{3}{7} =$

   1) $\frac{6}{11}$

   2) $\frac{3}{11}$

   3) $\frac{9}{11}$

   4) $\frac{9}{28}$

   5) $\frac{33}{28}$

2. $\dfrac{\frac{8}{7}}{\frac{3}{5}} =$

   1) $\frac{40}{21}$

   2) $\frac{24}{35}$

   3) $\frac{35}{24}$

   4) $\frac{21}{24}$

   5) $\frac{11}{12}$

3. $(-5) - (-9) =$

   1) 45

   2) 4

   3) -4

   4) 14

   5) -14

4. If $\frac{x}{5} = \frac{3}{2}$, then $x = ?$

   1) $2\frac{3}{5}$

   2) $1\frac{1}{5}$

   3) $7\frac{1}{2}$

   4) $-3\frac{1}{2}$

   5) $6\frac{1}{2}$

5. Which of the following is a simplified form of

   $\frac{8x^3 - 4x^2 + 2x}{2x}$?

   1) $8x^3 - 4x^2$

   2) $4x^2 - 2x + 1$

   3) $2x^3$

   4) $2x^3 + 1$

   5) $3x^2$

6. What is the value of $x^2 - ab$ if $x = 5$, $a = 4$, and $b = -6$?

1) 49

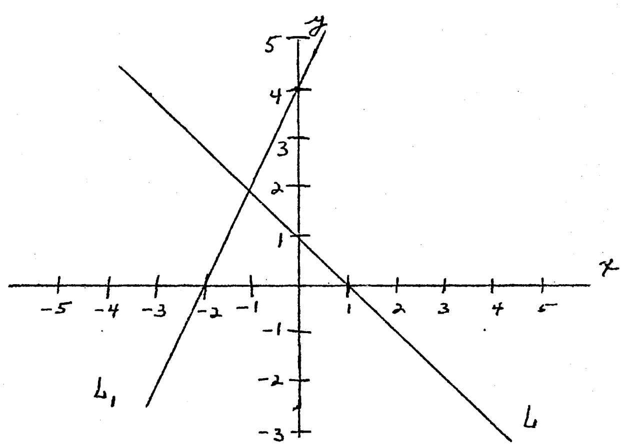
2) -49

3) 1

4) -1

5) -600

7.



The figure above shows the graphs of two linear equations. What is the solution of these equations?

1) (-2, 4)

2) (-1, 2)

3) (-2, 1)

4) (1, 4)

5) (1, 1)

8. 20% of 30 is _____.

   1) $\frac{2}{3}$

   2) 6

   3) 60

   4) 150

   5) 600

9. What is the solution of the following equation: $2x + 3 = -5$?

   1) $x = 0$

   2) $x = 4$

   3) $x = -4$

   4) $x = -1$

   5) $x = 1$

10. If $\frac{x}{3} - 1 = \frac{x}{5} + 2$, then $x = ?$

   1) -15

   2) $-\frac{2}{3}$

   3) $\frac{3}{2}$

   4) 15

   5) $\frac{45}{2}$

11. What is the value of the larger root of $x(x - 3) = 4$?

1) 7

2) 0

3) -1

4) 4

5) 3

12. Solve this pair of simultaneous equations for y.

$$\begin{aligned} 5x + 4y &= 0 \\ 3x + 5y &= 13 \end{aligned}$$

1) 1

2) 4

3) 5

4) 6

5) 8

13. Factor $3x^2 - 4x - 4$.

1) $(3x - 2)(x + 2)$

2) $(3x + 2)(x - 2)$

3) $(3x + 1)(x - 4)$

4) $(3x - 4)(x + 1)$

5) $(3x - 4)(x - 1)$

14. If $x = \frac{3}{5}$, then $x^{-2} = ?$

1) $-\frac{25}{9}$

2) $-\frac{6}{10}$

3) $-\frac{9}{25}$

4) $\frac{10}{6}$

5) $\frac{25}{9}$

15. Which of the following is a simplified expression of

$(a + b)^2 - (a - b)^2$?

1) $2b^2$

2) $4ab$

3) $a^2 + b^2$

4) $2a^2 + 2b^2$

5) ab

16. If $\cos \theta = \frac{4}{5}$ and θ is a fourth quadrant angle, what is the value of $\sin \theta$?

1) $\frac{1}{5}$

2) $\frac{-4}{3}$

3) $\frac{5}{4}$

4) $\frac{-3}{5}$

5) $\frac{5}{-3}$

17. If $\sin 26^{o} = \cos x$, which of the following is a value of x ?

1) 206^{o}

2) 64^{o}

3) 154^{o}

4) -26^{o}

5) 116^{o}

18. If $\tan \theta = .40$, then $\cot \theta = (?)$.

1) .40

2) .65

3) .60

4) 1.40

5) 2.50

19. Which of the following is a factor of $x^3 - 4x^2 - 3x + 12$?

1) $x + 4$

2) $x - 4$

3) $x - 3$

4) $x + 3$

5) $x - 2$

20. Simplify $\dfrac{\left(2a^2\right)^3 \left(ab^4\right)}{b}$

1) $8a^7b^3$

2) $6a^6b^2$

3) $2a^7b^3$

4) $2a^5b^2$

5) $8a^6b^4$

21. $\frac{3}{80}$ is the same as

1) .0375

2) .2666

3) .00375

4) .02666

5) .375

22. The altitude of a balloon T above the level ground is 2000 ft. If a weather station at point P on the ground sights the balloon at an angle of 56°, the distance TP is

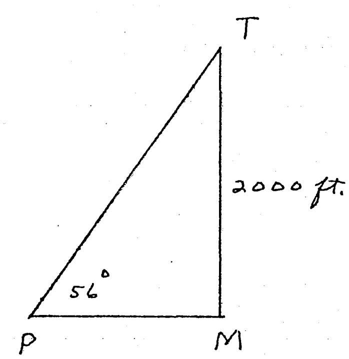
1) $\frac{2000}{\sin 56^{\circ}}$

2) $\frac{2000}{\cos 56^{\circ}}$

3) $2000 \sin 56^{\circ}$

4) $2000 \cos 56^{\circ}$

5) $2000 \tan 34^{\circ}$



23. If θ is an angle such that $\tan \theta = \frac{5}{12}$ and $\sin \theta = -\frac{5}{13}$ what is the value of $\sec \theta$?

1) $\frac{12}{5}$

2) $\frac{13}{12}$

3) $\frac{12}{13}$

4) $-\frac{12}{13}$

5) $-\frac{13}{12}$

24. Which of the following is another expression for sin 290° ?

 1) cos 20°

 2) sin 20°

 3) sin 70°

 4) $-$ cos 70°

 5) $-$ sin 70°

25. What are the positive solutions less than 2π of the equation $2 \sin \theta = 1$?

 1) $\frac{\pi}{6}$ and $\frac{11\pi}{6}$

 2) $\frac{\pi}{6}$ and $\frac{5\pi}{6}$

 3) $\frac{\pi}{3}$ and $\frac{2\pi}{3}$

 4) $\frac{\pi}{3}$ and $\frac{\pi}{6}$

 5) $\frac{\pi}{3}$ and $\frac{5\pi}{3}$

26. Which of the following is another expression for $\dfrac{x + y}{\frac{1}{x} + \frac{1}{y}}$?

 1) $x + y$

 2) $(x + y)^2$

 3) xy

 4) $\dfrac{xy}{x + y}$

 5) $\dfrac{x + y}{xy}$

27. What is the slope of the line whose equation is

$4y - 3x = 6$?

1) -3

2) $\frac{3}{2}$

3) $\frac{3}{4}$

4) 4

5) 6

28. Which of the following is the sum of the fractions

$\frac{2x}{2x - 1}$ and $\frac{1}{1 - 2x}$?

1) $2x - 1$

2) 1

3) -1

4) $\frac{2x + 1}{2x - 1}$

5) $-4x^2 + 4x - 1$

29. $\sin^2 2\theta + \cos^2 2\theta = ?$

1) 0

2) 1

3) 2

4) $\cos 4\theta$

5) $1 - 2 \sin 4\theta$

30. Which of the following trigonometric expressions is equivalent to the sum of sin 3 cos 2 and cos 3 sin 2 ?

1) sin 1

2) cos 1

3) sin 5

4) cos 5

5) $\sin \frac{5}{2}$

31. If θ is the acute angle for which $\sin \theta = \frac{4}{5}$, then $\sin 2\theta =$ (?) .

1) $\frac{8}{5}$

2) $\frac{24}{25}$

3) $\frac{12}{25}$

4) $\frac{9}{25}$

5) $\frac{-7}{25}$

32. If $2^{2x} = 64$, then x is

1) 3

2) 6

3) 12

4) 16

5) 32

33. $(1 + i)^2 = ?$

1) 0

2) 2

3) $2i$

4) $1 + i$

5) $2 + 2i$

34. If $\cos\theta = \frac{3}{4}$, and $0 < \theta < \frac{\pi}{2}$, what is θ ?

1) 60°

2) $\frac{\pi}{3}$

3) arc cos $\frac{3}{4}$ or $\cos^{-1}\frac{3}{4}$

4) arc cos $\frac{4}{3}$ or $\cos^{-1}\frac{4}{3}$

5) The equation has no solution

35. Solve the equation $\sin x - \cos x = 0$ for all positive values of x less than 360° .

1) 45°

2) 45° and 135°

3) 45° and 225°

4) 45°, 135°, 225°, 315°

5) 225° and 315°

36. The period of the function $y = f(x) = 3 \sin 2\theta$ is

1) 3

2) π

3) 2

4) $\frac{1}{\pi}$

5) $\frac{\pi}{2}$

37. In the oblique triangle LMN, $LM = 8$, $MN = 10$, and $LN = 12$. $\frac{\sin L}{\sin M} = (?)$.

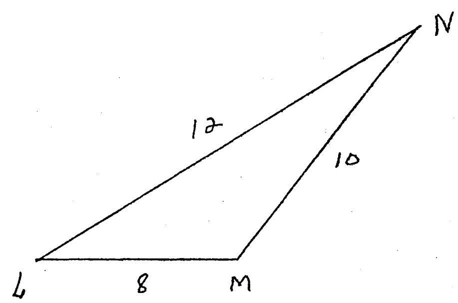
1) $\frac{3}{4}$

2) $\frac{4}{5}$

3) $\frac{5}{6}$

4) $\frac{6}{5}$

5) $\frac{5}{4}$



38. If $f(x) = 2x + 1$ and $g(x) = \frac{1}{\sqrt{x}}$, then $f\left(g(x)\right) = ?$

1) $\frac{2x + 1}{\sqrt{x}}$

2) $\frac{1}{\sqrt{2x + 1}}$

3) $\frac{2}{\sqrt{x}} + 1$

4) $2x + 1 + \frac{1}{\sqrt{x}}$

5) $(2x + 1)\sqrt{x}$

39. The polynomial $8x^3 - 27$ can be expressed in factor form as

1) $(2x - 3)(2x - 3)(2x - 3)$

2) $(8x - 3)(x^2 + 9)$

3) $(8x + 3)(x - 3)(x + 3)$

4) $(2x - 3)(4x^2 + 6x + 9)$

5) $(2x - 3)(4x^2 - 6x + 9)$

40. $2\sqrt{12} + 3\sqrt{48} - 5\sqrt{27} = ?$

1) $\sqrt{3}$

2) $\sqrt{12}$

3) $\sqrt{27}$

4) $\sqrt{48}$

5) $\sqrt{58}$

APPENDIX C

FORMULAS

Kuder-Richardson Formula Number 20 (Guilford, 1965, p. 459)

$$r = \frac{n}{n - 1}\left[1 - \frac{\Sigma pq}{s^2}\right] \quad \text{where}$$

p = number of correct responses divided by the number of students

q = 1 - p

n = number of items on the test

s^2 = variance of the test

Point-Biserial Coefficient of Correlation (Guilford, 1965, p. 322)

$$r_{pb} = \frac{M_p - M_q}{\sigma}\sqrt{pq} \quad \text{where}$$

M_p = mean of the scores for the higher group in the dichotomized variable, the one having more of the ability on which the sample is divided into two subgroups.

M_q = mean of the scores for the lower group.

p = proportion of the persons in the higher group.

q = proportion of the persons in the lower group.

σ = the standard deviation of the total sample in the continuously measured variable.

Pearson's Product-moment Coefficient of Correlation (Bruning and Kintz, 1968, p. 153)

$$r = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{[N\Sigma X^2 - (\Sigma X)^2][N\Sigma Y^2 - (\Sigma Y)^2]}} \quad \text{where}$$

N = number of pairs of scores

ΣXY = sum of the products of the paired scores

ΣX = sum of the scores on one variable

ΣY = sum of the scores on the other variable

ΣX^2 = sum of the squared scores on the X variable

ΣY^2 = sum of the squared scores on the Y variable.

Multiple Correlation Coefficient (Guilford, 1965, p. 394)

$$R^2_{1.23} = \frac{r^2_{12} + r^2_{13} - 2r_{12}r_{13}r_{23}}{1 - r^2_{23}} \quad \text{where}$$

r_{12} = correlation coefficient between the placement test scores and the Mathematics ACT scores

r_{13} = correlation coefficient between the placement test scores and the first quarter college mathematics grades

r_{23} = correlation coefficient between the Mathematics ACT scores and the first quarter college mathematics grades

$R_{1.23}$ = square root of $R^2_{1.23}$ is the coefficient of multiple correlation between the placement test scores and a combination of the first quarter college mathematics grades and the Mathematics ACT scores.

APPENDIX D

DISCRIMINANT ANALYSIS

The following procedure for using the discriminant function is from Edward Bryant (1966, pp. 238-241). Formally, let

$$V_i = a_1X_{1i} + a_2X_{2i} + \ldots + a_pX_{pi}.$$

Find the a_j such that the average value of V for the AB group will be the maximum normalized distance away from the average V for the DF group in each course. The X_{ki}, $1 \le k \le 6$, are the part scores of the AB or DF groups.

The procedure for using the discriminant function is as follows. Let n be the total number of students in a particular freshman mathematics course Z of which n_a are from the AB group and n_b are from the DF group. Compute the adjusted sum of squares and cross products of each group separately, i.e.

$$S^a_{ij} = \sum^{n_a} X_iX_j - \frac{(\sum^{n_a} X_i)(\sum^{n_a} X_j)}{n_a}$$

$$S^b_{ij} = \sum^{n_b} X_iX_j - \frac{(\sum^{n_b} X_i)(\sum^{n_b} X_j)}{n_b}$$

Adding the adjusted sums of squares for the AB group and the DF group, one obtains,

$$S'_{ij} = S^a_{ij} + S^b_{ij} .$$

Now set up the following system of linear equations:

$$S'_{11}a_1 + S'_{12}a_2 + \ldots + S'_{1p}a_p = d_1$$

$$S'_{21}a_1 + S'_{22}a_2 + \ldots + S'_{2p}a_p = d_2$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$S'_{p1}a_1 + S'_{p2}a_2 + \ldots + S'_{pp}a_p = d_p$$

where $d_j = X_j^a - X_j^b$, that is the difference between the means of the j variable. Solve this system of linear equations for a_1, a_2, . . . , a_p. The average value of V for the AB group of Mathematics Z is found as

$$\overline{V}^a = a_1\overline{X}_1^a + a_2\overline{X}_2^a + \ldots + a_p\overline{X}_p^a$$

and DF group of Mathematics Z as

$$\overline{V}^b = a_1\overline{X}_1^b + a_2\overline{X}_2^b + \ldots + a_p\overline{X}_p^b.$$

The cutoff points for choosing between AB group of Mathematics Z and DF group of Mathematics Z lies between $\overline{V}^a$ and $\overline{V}^b$.

A test of the hypothesis that the discriminant function has no discriminating ability was provided by the F test below (Bryant, 1966, p. 239):

$$F = \frac{\left[n_a n_b/(n_a + n_b)\right] D^2/p}{D/(n - p - 1)} \qquad \text{with p and } n - p - 1 \text{ df}$$

where $D = \overline{V}^a - \overline{V}^b = \Sigma a_j d_j$.

APPENDIX E

PLACEMENT DATA RECEIVED BY STUDENT ADVISORS

TO: Academic Advisers

FROM: Emery Gathers
Department of Mathematics and Computer Science

SUBJECT: Mathematics Placement Information

We recommend the following procedure that an adviser should use in an effort to place a student in the proper mathematics course. Included are examples and explanations on the use of the information on the attached Mathematics Placement Results Sheet. The adviser should begin with "I" below with each advisee.

I. Does the student have a <u>university</u> determined deficiency in algebra?
 NO: Go to II below.
 YES: For one high school unit of deficiency a student must take Core Mathematics 1001. (Not counted toward any degree requirement.)
 For ½ unit of deficiency a student must take Core Mathematics 1001 or Core Mathematics 1002. (For placement, see Mathematics Placement Results Sheet and V below.)
 The student must follow Core Mathematics 1001 with Core Mathematics 1002. (Each is not counted toward any degree requirements.)

II. Does the student need or wish to take Calculus 1810? (A student who needs more than one year of mathematics should plan to take Calculus 1810. Also, a student may desire to protect an option to change his program of study at a later date to one which requires Calculus 1810.)
 NO: Go to IV below.
 YES: (Find the student's name on the Mathematics Placement Results Sheet.)
 Go to IIIA.

IIIA. Does the student have a <u>YES</u> in the 1810 column?
 YES: Student should take Calculus 1810.
 NO: Go to IIIB.

IIIB. Does the student have a <u>YES</u> in the 1600 column?
 YES: Student should take Precalculus Mathematics 1600.
 Note: The student may take Precalculus Mathematics 1600 and Calculus 1810 to satisfy the minimum mathematics requirements for the B.S. degree in Liberal Arts.
 NO: Go to IIIC.

IIIC. Does the student have a YES in the 1040 column?

YES: Student should take Trigonometry 1040. If a student feels that he is weak in algebra, he may enroll in College Algebra 1300 concurrently with Trigonometry 1040.

NO: Go to IIID.

IIID. Does the student have a YES in the 1110 column?

YES: The student may enroll in College Algebra 1300 or General Mathematics 1110.

NO: If the student has a YES in the 1002 column he should enroll in Core Mathematics 1002. If the student has a NO in the 1002 column he should enroll in Core Mathematics 1001.

IV. The student should be placed in General Mathematics 1110, Core Mathematics 1002, or Core Mathematics 1001. Use the Mathematics Placement Results Sheet and some personal counseling to make a determination. See V for examples and explanations.

V. Examples and explanations for placing students in freshman mathematics courses. The Mathematics Placement Results Sheet will have the following format:

Name	1810	1600	1040	1110	1002	1001	Math ACT	HS GPA
King, Billie	NO	NO	NO	NO	YES	YES	12	2.03
Long, Cleo	NO	NO	YES	YES	YES	YES	22	2.89
Newton, Isaac	YES	YES	YES	YES	YES	YES	30	3.56
Young, Tim	NO	NO	NO	YES	YES	YES	21	2.74

The results of the Mathematics Placement Sheet indicate Ms. King is qualified for Core Mathematics 1002. However, the low ACT and GPA scores indicate the need for some personal counseling and possibly a lower placement.

The results of the Mathematics Placement Sheet indicate Ms. Cleo Long is qualified for Trigonometry 1040. She is also qualified for General Mathematics 1110.

The results of the Mathematics Placement Sheet indicate Mr. Newton is qualified for Calculus 1810 and that Mr. Young is qualified for General Mathematics 1110.

NAME			1810	1600	1040	1110	1002	1001	MATH ACT	HS GPA
ABLES	DAVID	L	NO	NO	YES	YES	YES	YES		2.17
ADAMS	DEBORA	L	NO	NO	NO	YES	YES	YES	23	3.51
ADCOCK	R	J	NO	NO	NO	YES	YES	YES	19	3.13
AKIN	MELVA	J	NO	NO	NO	YES	YES	YES	09	2.50
AKINS	BARRY	L	NO	NO	NO	YES	YES	YES	21	2.37
ALBERT	SUSAN	H	NO	NO	NO	NO	NO	YES		
ALEXANDER	JAN	E	NO	NO	NO	YES	YES	YES	18	3.39
ALLEN	GREGOR	S	NO	NO	NO	YES	YES	YES	20	3.23
ALLEN	MILDRE	J	NO	NO	NO	YES	YES	YES	19	3.36
ALLEY	ANDREA	D	NO	NO	NO	NO	NO	YES	07	3.34
ALLISON	RYAN	J	NO	NO	NO	YES	YES	YES	18	2.45
ALLRED	CATHY	L	NO	NO	NO	NO	YES	YES	16	3.17
ALRUTZ	ELAINE	M	YES	YES	YES	YES	YES	YES	19	3.33
ALTMAN	TERESA	F	NO	NO	NO	YES	YES	YES	20	2.69
ANCELL	LINDA	K	NO	NO	NO	NO	YES	YES	10	1.91
ANDERSON	BILLY	M	NO	NO	NO	NO	NO	YES	12	2.55
ANDERSON	SHARON		NO	NO	NO	NO	NO	YES	06	2.14
ANDREWS	JUDY	A	NO	NO	NO	YES	YES	YES		
ANGNER	JOHN	L	NO	NO	NO	YES	YES	YES	26	2.69
ARRIOLA	JOHN	H	NO	NO	NO	NO	NO	YES	13	2.46
ASHLEY	VICKIE	L	NO	NO	NO	NO	YES	YES	22	2.99
ATKINS	SHARON	F	NO	NO	NO	NO	NO	YES	10	2.97
ATNIP	JOSEPH	P	YES	YES	YES	YES	YES	YES		
AVERY	CATHER	M	NO	NO	NO	NO	YES	YES	16	2.93
AYERS	RONALD	W	NO	NO	NO	YES	YES	YES	27	3.16
BACIGALUPO	WILLIA	A	NO	NO	NO	YES	YES	YES	25	4.00
BAGBY	GAIL	C	NO	NO	NO	NO	YES	YES	19	3.03
BAILEY	WILLIA	A	NO	NO	NO	NO	YES	YES	08	2.87
BAKER	FLOYD	R	NO	NO	NO	YES	YES	YES	15	2.38
BAKER	LONDA	K	YES	YES	YES	YES	YES	YES	27	
BAKER	SAMUEL	C	NO	NO	NO	YES	YES	YES	19	2.41
BARKLEY	JOHN	E	NO	NO	NO	NO	NO	YES		

APPENDIX F

COMPUTER PROGRAMS

```
C RELIABILITY PROGRAM
C  KUDER-RICHARDSON FORMULA 20 RELIABILITY COEFFICIENTS FOR
C PART SCORES OF THE UTM MATHEMATICS PLACEMENT EXAMINATION
      REAL      NAR(820),NAL(820),NTR(820),NAA(820),NAT(820),NT(820)
      DIMENSION P(40),Q(40),R(40)
      GOAT(X)=IFIX(X+0.5)
      DO 19 K=1,820
      NAR(K)=0
      NAL(K)=0
      NTR(K)=0
      NAA(K)=0
      NAT(K)=0
   19 NT(K)=0
      L=0
      SAR=0.0
      SAR2=0.0
      SAL=0.0
      SAL2=0.0
      STR=0.0
      STR2=0.0
      SAA=0.0
      SAA2=0.0
      SAT=0.0
      SAT2=0.0
      ST=0.0
      ST2=0.0
      SPQ=0.0
      SPQA=0.0
      SPQAL=0.0
      SPQT=0.0
      SPQAA=0.0
      SPQAT=0.0
      READ(2,20)(R(J),J=1,40)
   20 FORMAT(20F3.0)
    5 READ(2,10)BAR,BAL,BTR,BAA,BAT,BT
   10 FORMAT(29X,6F3.0)
      IF(BT-0.0)2,3,4
    3 GO TO 5
    4 L=L+1
      NAR(L)=GOAT(0.06*BAR)
      NAL(L)=GOAT(0.20*BAL)
      NTR(L)=GOAT(0.14*BTR)
```

```
      NAA(L)=GOAT(0.26*BAA)
      NAT(L)=GOAT(0.34*BAT)
      NT(L)=GOAT(0.40*BT)
      GO TO 5
    2 CONTINUE
      M=L
      A=M
      DO 13 J=1,40
      P(J)=R(J)/A
      Q(J)=1.0-P(J)
   13 SPQ=SPQ+P(J)*Q(J)
      DO 14 J=1,M
      SAR=SAR+NAR(J)
      SAR2=SAR2+NAR(J)*NAR(J)
      SAL=SAL+NAL(J)
      SAL2=SAL2+NAL(J)*NAL(J)
      STR=STR+NTR(J)
      STR2=STR2+NTR(J)*NTR(J)
      SAA=SAA+NAA(J)
      SAA2=SAA2+NAA(J)*NAA(J)
      SAT=SAT+NAT(J)
      SAT2=SAT2+NAT(J)*NAT(J)
      ST=ST+NT(J)
   14 ST2=ST2+NT(J)*NT(J)
      FMAR=SAR/A
      FMAL=SAL/A
      FMTR=STR/A
      FMAA=SAA/A
      FMAT=SAT/A
      FMT=ST/A
      SAR=SAR*SAR
      SAL=SAL*SAL
      STR=STR*STR
      SAA=SAA*SAA
      SAT=SAT*SAT
      ST=ST*ST
      SDAR2=(SAR2-(SAR/A))/A
      SDAR=SQRT(SDAR2)
      SDAL2=(SAL2-(SAL/A))/A
      SDAL=SQRT(SDAL2)
      SDTR2=(STR2-(STR/A))/A
      SDTR=SQRT(SDTR2)
```

```
      SDAA2=(SAA2-(SAA/A))/A
      SDAA=SQRT(SDAA2)
      SDAT2=(SAT2-(SAT/A))/A
      SDAT=SQRT(SDAT2)
      SDT2=(ST2-(ST/A))/A
      SDT=SQRT(SDT2)
      SPQA=P(1)*Q(1)+P(2)*Q(2)+P(3)*Q(3)+P(8)*Q(8)+P(21)*Q(21)
     -+P(40)*Q(40)
      SPQA1=P(4)*Q(4)+P(5)*Q(5)+P(6)*Q(6)+P(7)*Q(7)+P(9)*Q(9)
      SPQA3=P(11)*Q(11)+P(12)*Q(12)+P(13)*Q(13)+P(14)*Q(14)+P(15)*Q(15)
      SPQA5=       P(20)*Q(20)+P(26)*Q(26)+P(27)*Q(27)+P(28)*Q(28)
      SPQA6=       P(33)*Q(33)+P(38)*Q(38)+P(39)*Q(39)
      SPQA4=P(10)*Q(10)+P(19)*Q(19)+P(32)*Q(32)
      SPQAL=SPQA1+SPQA3+SPQA5+SPQA6+SPQA4
      SPQB=P(16)*Q(16)+P(17)*Q(17)+P(18)*Q(18)+P(22)*Q(22)+P(23)*Q(23)
      SPQT1=       P(25)*Q(25)+P(29)*Q(29)+P(30)*Q(30)+P(31)*Q(31)
      SPQT2=       P(35)*Q(35)+P(36)*Q(36)+P(37)*Q(37)
      SPQT3=P(24)*Q(24)+P(34)*Q(34)
      SPQT=SPQB+SPQT1+SPQT2+SPQT3
      SPQAA=SPQA+SPQAL
      SPQAT=SPQAL+SPQT
      D=6.0
      G=20.0
      F=14.0
      X=34.0
      Y=26.0
      Z=40.0
      RELA=(D/(D-1.0))*(1.0-(SPQA)/SDAR2)
      RELAL=(G/(G-1.0))*(1.0-(SPQAL)/SDAL2)
      RELTR=(F/(F-1.0))*(1.0-(SPQT)/SDTR2)
      RELAA=(Y/(Y-1.0))*(1.0-(SPQAA)/SDAA2)
      RELAT=(X/(X-1.0))*(1.0-(SPQAT)/SDAT2)
      RELT=(Z/(Z-1.0))*(1.0-(SPQ)/SDT2)
      WRITE(5,400)
  400 FORMAT(1X,' ARITH')
      WRITE(5,500) FMAR,SDAR,RELA,M,L
  500 FORMAT(1X,' MEAN = ',F10.5,3X,' SD = ',F10.5,3X,' RELIABILITY = '
     -,F10.5,3X,' N = ',I3,3X,I3//)
      WRITE(5,401)
  401 FORMAT(1X,' ALG')
      WRITE(5,500) FMAL,SDAL,RELAL,M,L
      WRITE(5,402)
```

```
  402 FORMAT(1X,' TRIG')
      WRITE(5,500) FMTR,SDTR,RELTR,M,L
      WRITE(5,403)
  403 FORMAT(1X,' ARITH AND ALG')
      WRITE(5,500) FMAA,SDAA,RELAA,M,L
      WRITE(5,404)
  404 FORMAT(1X,' AGL AND TRIG')
      WRITE(5,500) FMAT,SDAT,RELAT,M,L
      WRITE(5,405)
  405 FORMAT(1X,' TOTAL')
      WRITE(5,500) FMT,SDT,RELT,M,L
      CALL EXIT
      END
```

```
C VALIDITY, TOTAL GRADE (POINT BISERIAL), TOTAL MATH ACT (PEARSON),
C MATH ACT GRADES (POINT BISERIAL), MULTIPLE CORRELATION
      DIMENSION T(820),ACT(820),GRAD(820),N(12),M(12)
      DATA A,B,C,D,F,Z/'A','B','C','D','F','Z'/
      DO 999 J1=1,7
      DO 2 K=1,820
      T(K)=0.0
      ACT(K)=0.0
    2 GRAD(K)=Z
      DO 3 K=1,12
      N(K)=0
    3 M(K)=0
      L=0
      SX=0.0
      SXY=0.0
      SY=0.0
      SYY=0.0
      SXX=0.0
      RPA=0.0
      SA=0.0
      SAA=0.0
      SB=0.0
      SBB=0.0
      SC=0.0
      SCC=0.0
      SD=0.0
      AGL=0.0
      SDD=0.0
      AGT=0.0
      SF=0.0
      FMAGH=0.0
      SFF=0.0
      FMAGL=0.0
      AS=0.0
      PAG=0.0
      AAS=0.0
      QAG=0.0
      BS=0.0
      SDAG=0.0
      BBS=0.0
      RAG=0.0
      CS=0.0
```

```
      RRR=0.0
      CCS=0.0
      SM=0.0
      DS=0.0
      DDS=0.0
      FS=0.0
      XM=0.0
      FFS=0.0
      YM=0.0
      HNH=0.0
      TM=0.0
      HNL=0.0
      HNT=0.0
      FMH=0.0
      FML=0.0
      P=0.0
      Q=0.0
      SDEV=0.0
      RPG=0.0
      AGH=0.0
    5 READ(2,10)BT,BACT,BGRAD
   10 FORMAT(44X,F3.0,F2.0,3X,A1)
      IF(BT-0.0)6,7,8
    7 GO TO 5
    8 L=L+1
      T(L)=BT
      ACT(L)=BACT
      GRAD(L)=BGRAD
      GO TO 5
    6 CONTINUE
      DO 15 J=1,L
      IF(ACT(J)-0.0) 15,15,14
   14 M(1)=M(1)+1
      SXY=SXY+ACT(J)*T(J)
      SXX=SXX+ACT(J)*ACT(J)
      SYY=SYY+T(J)*T(J)
      SX=SX+ACT(J)
      SY=SY+T(J)
   15 CONTINUE
      TM=M(1)
      SDA=SQRT((SXX-(SX**2)/TM)/TM)
      XM=SX/TM
```

```
      YM=SY/TM
      SDT=SQRT((SYY-(SY**2)/TM)/TM)
      RPA=( TM *SXY-SX*SY)/SQRT(( TM *SXX-SX*SX)*( TM *SYY-SY*SY))
      DO 16 J=1,L
      IF(GRAD(J)-A)16,17,16
   17 N(1)=N(1)+1
      SA=SA+T(J)
      SAA=SAA+T(J)*T(J)
      IF(ACT(J)-0.0)16,16,170
  170 M(2)=M(2)+1
      AS=AS+ACT(J)
      AAS=AAS+ACT(J)*ACT(J)
   16 CONTINUE
      DO 18 K=1,L
      IF(GRAD(K)-B) 18,19,18
   19 N(2)=N(2)+1
      SB=SB+T(K)
      SBB=SBB+T(K)*T(K)
      IF(ACT(K)-0.0)18,18,190
  190 M(3)=M(3)+1
      BS=BS+ACT(K)
      BBS=BBS+ACT(K)*ACT(K)
   18 CONTINUE
      DO 20 K=1,L
      IF(GRAD(K)-C) 20,21,20
   21 N(3)=N(3)+1
      SC=SC+T(K)
      SCC=SCC+T(K)*T(K)
      IF(ACT(K)-0.0) 20,20,210
  210 M(4)=M(4)+1
      CS=CS+ACT(K)
      CCS=CCS+ACT(K)*ACT(K)
   20 CONTINUE
      DO 22 K=1,L
      IF(GRAD(K)-D)22,23,22
   23 N(4)=N(4)+1
      SD=SD+T(K)
      SDD=SDD+T(K)*T(K)
      IF(ACT(K)-0.0)22,22,230
  230 M(5)=M(5)+1
      DS=DS+ACT(K)
      DDS=DDS+ACT(K)*ACT(K)
```

```
   22 CONTINUE
      DO 24 K=1,L
      IF(GRAD(K)-F)24,25,24
   25 N(5)=N(5)+1
      SF=SF+T(K)
      SFF=SFF+T(K)*T(K)
      IF(ACT(K)-0.0)24,24,250
  250 M(6)=M(6)+1
      FS=FS+ACT(K)
      FFS=FFS+ACT(K)*ACT(K)
   24 CONTINUE
      HNH=N(1)+N(2)+N(3)
      HNL=N(4)+N(5)
      HNT=HNH+HNL
      FMH=(SA+SB+SC)/HNH
      FML=(SD+SF)/HNL
      P=HNH/HNT
      Q=HNL/HNT
      SDEV=SQRT(((SAA+SBB+SCC+SDD+SFF)-((SA+SB+SC+SD+SF)**2)/HNT) /HNT)
      RPG=(FMH-FML)*(SQRT(P*Q))/SDEV
      AGH=M(2)+M(3)+M(4)
      AGL=M(5)+M(6)
      AGT=AGH+AGL
      FMAGH=(AS+BS+CS)/AGH
      FMAGL=(DS+FS)/AGL
      PAG=AGH/AGT
      QAG=AGL/AGT
      SDAG=SQRT(((AAS+BBS+CCS+DDS+FFS )-((AS+BS+CS+DS+FS )**2)/AGT)/AGT)
      RAG=(FMAGH-FMAGL)*(SQRT(PAG*QAG))/SDAG
      RRR=((RPG**2)+(RPA**2)-(2.0*RPG*RPA*RAG))/(1.0-RAG**2)
      RRXX=SQRT(RRR)
      WRITE(5,100)
  100 FORMAT(1X,' VALIDITY TOTAL-MATH ACT  PEARSON '/)
      WRITE(5,200) YM,XM,SDT,SDA,RPA,TM
  200 FORMAT(1X,' XT= ',F10.5,3X,' XA= ',F10.5,3X,' SDT= ',F10.5,3X,
     -' SDA= ',F10.5,3X,' VALPA= ',F10.6,3X,' N = ',F9.0//)
      WRITE(5,300)
  300 FORMAT(1X,' VALIDITY TOTAL-GRADE POINT BISERIAL '/)
      WRITE(5,400) HNH,HNL,P,Q
  400 FORMAT(1X,' NOHG= ',F9.0,3X,' NOLG= ',F9.0,3X,' P= ',F10.5,3X,
     -' Q= ',F10.5/)
      WRITE(5,700)FMH,FML,SDEV,RPG
```

```
  700 FORMAT(1X,' MHG= ',F10.5,3X,' MLG= ',F10.5,3X,' SD= ',F10.5,3X,
     -' VAL= ',F10.6//)
      WRITE(5,500)
  500 FORMAT(1X,' VALIDITY MATH ACT-GRADE-POINT BISERIAL '/)
      WRITE(5,400) AGH,AGL,PAG,QAG
      WRITE(5,700)FMAGH,FMAGL,SDAG,RAG
      WRITE(5,600) RRXX
  600 FORMAT(1X,' MULTIPLE CORRELATION = ',F10.6/)
      WRITE(5,900) L
  900 FORMAT(1X,' L= ',I4/)
  999 CONTINUE
      CALL EXIT
      END
```

```
C AB GROUPS AND DF GRCUPS
      REAL NG(360)
      DIMENSION NAR(360),NAL(360),NTR(360),NAA(360),NAT(360),
     -NT(360)
      DATA A,B,D,F,Z/'A','B','D','F','Z'/
      DO 19 K=1,360
      NAR(K)=0
      NAL(K)=0
      NTR(K)=0
      NAA(K)=0
      NAT(K)=0
      NT(K)=0
   19 NG(K)=Z
      J4=0
      J5=0
      J6=0
      J7=0
      J8=0
      J9=0
      L=0
      M=0
      READ(2,555) LUM
  555 FORMAT(77X,I3)
    5 READ(2,10)JAR,JAL,JTR,JAA,JAT,JT,JMA,JHS,RG
   10 FORMAT(29X,6I3,I2,I3,A1)
      IF(JT-0)2,3,4
    3 GO TO 5
    4 L=L+1
      NAR(L)=JAR
      NAL(L)=JAL
      NTR(L)=JTR
      NAA(L)=JAA
      NAT(L)=JAT
      NT(L)=JT
      NG(L)=RG
      GO TO 5
    2 CONTINUE
      READ(2,10)  LLL
      DO 88 K=1,L
      IF(NG(K)-A) 88,67,88
   67 J4=J4+1
      WRITE(2,12)NAR(K),NAL(K),NTR(K),NAA(K),NAT(K),NT(K)
```

```
   88 CONTINUE
      DO 111 K=1,L
      IF(NG(K)-B) 111,110,111
  110 J5=J5+1
      WRITE(2,12)NAR(K),NAL(K),NTR(K),NAA(K),NAT(K),NT(K)
  111 CONTINUE
      WRITE(2,555) LUM
      DO 131 K=1,L
      IF(NG(K)-D) 131,130,131
  130 J7=J7+1
      WRITE(2,12)NAR(K),NAL(K),NTR(K),NAA(K),NAT(K),NT(K)
  131 CONTINUE
      DO 141 K=1,L
      IF(NG(K)-F) 141,140,141
  140 J8=J8+1
      WRITE(2,12)NAR(K),NAL(K),NTR(K),NAA(K),NAT(K),NT(K)
  141 CONTINUE
   12 FORMAT(1X,6I3)
      J6=J4+J5
      J9=J7+J8
      WRITE(5,666) J6,J9
  666 FORMAT(3X,I4,5X,I4)
      CALL EXIT
      END
```

```
C PROGRAM FOR TWO GROUPS DISCRIMINANT FUNCTION
C COMPUTER PROGRAM IV WAS TAKEN FROM OVERALL AND
C  KLETT (1972, PP. 276-279)
      SUBROUTINE RMINV(A,N)
      DIMENSION IPIVO(18),INDEX(18,2),PIVOT(18),A(18,18)
      DET=1.0
      DO 20 J=1,N
   20 IPIVO(J)=0
      DO 550 I=1,N
      AMAX=0.0
      DO 105 J=1,N
      IF(IPIVO(J)-1) 60,105,60
   60 DO 100 K=1,N
      IF(IPIVO(K)-1) 80,100,740
   80 IF(ABS(AMAX)-ABS(A(J,K)))85,100,100
   85 IROW=J
      ICOLU=K
      AMAX=A(J,K)
  100 CONTINUE
  105 CONTINUE
      IF(ABS(AMAX)-2.0E-7) 800,800,801
  800 WRITE(5,666)
  666 FORMAT(20H DETERMINANT = ZERO )
      DET=0.0
      PAUSE
  801 CONTINUE
      IPIVO(ICOLU )=IPIVO (ICOLU )+1
      IF(IROW-ICOLU) 140,260,140
  140 DET=-DET
      DO 200 L=1,N
      SWAP=A(IROW,L)
      A(IROW,L)=A(ICOLU,L)
  200 A(ICOLU,L)=SWAP
  260 INDEX(I,1)=IROW
      INDEX(I,2)=ICOLU
      PIVOT(I)=A(ICOLU,ICOLU)
      DET=DET*PIVOT(I)
      A(ICOLU,ICOLU)=1.0
      DO 350 L=1,N
  350 A(ICOLU,L)=A(ICOLU,L)/PIVOT(I)
      DO 550 L1=1,N
      IF(L1-ICOLU) 400,550,400
```

```
  400 T=A(L1,ICOLU)
      A(L1,ICOLU)=0.0
      DO 450 L=1,N
  450 A(L1,L)=A(L1,L)-A(ICOLU,L)*T
  550 CONTINUE
      DO 710 I=1,N
      L=N+1-I
      IF(INDEX(L,1)-INDEX(L,2)) 630,710,630
  630 IROW=INDEX(L,1)
      ICOLU=INDEX(L,2)
      DO 705 K=1,N
      SWAP=A(K,IROW)
      A(K,IROW)=A(K,ICOLU)
      A(K,ICOLU)=SWAP
  705 CONTINUE
  710 CONTINUE
  740 RETURN
      END

CORE REQUIREMENTS FOR RMINV
 COMMON      0  VARIABLES    172  PROGRAM    540

RELATIVE ENTRY POINT ADDRESS IS 00C4 (HEX)

END OF COMPILATION

// DUP

*STORE      WS  UA  RMINV
D 06 ENTRY POINT NAME ALREADY IN LET/FLET


// FOR
*IOCS(CARD,DISK,1403PRINTER)
*LIST SOURCE PROGRAM
**      COMPUTER PROGRAM IV
```

```
      DIMENSION ASUM(18),A(18,18),WCOV(18,18),DATA(36),XBAR(2,18),NG(2),
     -DIFF(18),W(18),XMEAN(2),Y(3500),NSUM(101),MSUM(101)
      DEFINE FILE 1( 1500,80,U,L1)
    3 FORMAT(4I4)
    4 FORMAT(4X,'GROUP MEANS ON DISC. FUNCTION')
    5 FORMAT(1X,'FREQUENCY DISTRIBUTION OF DISCRIMINANT FUNCTION SCORES'
     1/,6X,'GP.1',8X,'GP.2',4X,'SCORE')
    6 FORMAT(10X,'MEANS ON ORIGINAL VARIABLES')
    7 FORMAT(1X,'DECILE FREQUENCIES AND PROPORTIONS',/,10X,'GROUP 1',15X
     1,'GROUP 2')
    9 FORMAT(11F7.4,/,5F7.4)
   10 FORMAT(13F6.3,/,3F6.3)
   11 FORMAT(20X,'COVARIANCE MATRIX')
   12 FORMAT(15X,'INVERSE OF COVARIANCE MATRIX')
   13 FORMAT(2X,'D-SQUARE',3X,'F')
   14 FORMAT(10X,'DISCRIMINANT FUNCTION COEFFICIENTS')
      L1=1
      READ(2,3) NVAR,(NG(I),I=1,2),NTAG
C COMPUTE THE WITHIN GROUPS COVARIANCE MATRIX
      TOT=0.0
      DO 20 M=1,NVAR
      W(M)=0.0
      ASUM(M)=0.0
      DO 20 M2=1,NVAR
        A(M,M2)=0.0
   20 WCOV(M,M2)=0.0
      FN1=NG(1)
      FN2=NG(2)
      DF=FN1+FN2-2.0
      NGPS=2
      IF(NTAG)1,2,1
    1 READ(2,10)((WCOV(M,M2),M2=1,NVAR),M=1,NVAR)
      READ(2,9)((XBAR(M,M2),M2=1,NVAR),M=1,2)
      GO TO 15
    2 DO 126 K=1,NGPS
      DO 526 J5=1,NVAR
  526 ASUM(J5)=0.0
      NX=NG(K)
      FNX=NX
      TOT=TOT+FNX
      FFNX=FNX-2
      DO 25 J=1,NX
```

```
PAGE    5                          COMPUTER PROGRAM IV
  139 FORMAT(10F10.3)
      NVAR2=NVAR*2
  567 FORMAT(1X,6F3.0)
      READ(2,567)(DATA(M5),M5=1,NVAR)
      WRITE(1'L1)(DATA(M5),M5=1,NVAR)
      DO 25 M=1,NVAR
      ASUM(M)=ASUM(M)+DATA(M)
      DO 25 M2=M,NVAR
      XDAT=DATA(M)*DATA(M2)
      A(M,M2)=A(M,M2)+XDAT
   25 CONTINUE
      DO 26 M=1,NVAR
      XBAR(K,M)=ASUM(M)/FNX
      DO 26 M2=M,NVAR
      WCOV(M,M2)=WCOV(M,M2)+A(M,M2)-ASUM(M)*ASUM(M2)/FFNX
   26 A(M,M2)=0.0
  126 CONTINUE
      WRITE(5,6)
      WRITE(5,139)(XBAR(1,M),M=1,NVAR)
      WRITE(5,139)(XBAR(2,M),M=1,NVAR)
      WRITE(5,11)
      DO 227 M=1,NVAR
      DO 227 M2=M,NVAR
      WCOV(M,M2)=WCOV(M,M2)/DF
  227 WCOV(M2,M)=WCOV(M,M2)
   15 DO 16 M=1,NVAR
   16 WRITE(5,139)(WCOV(M,M2),M2=1,NVAR)
C TAKE INVERSE OF WITHIN GROUPS COVARIANCE MATRIX
      CALL RMINV(WCOV,NVAR)
      WRITE(5,12)
      DO 17 M=1,NVAR
   17 WRITE(5,139)(WCOV(M,M2),M2=1,NVAR)
      DO 127 M=1,NVAR
      DIFF(M)=XBAR(1,M)-XBAR(2,M)
  127 CONTINUE
      DO 130 M=1,NVAR
      DO 130 M2=1,NVAR
  130 W(M)=W(M)+WCOV(M,M2)*DIFF(M2)
      WRITE(5,14)
      WRITE(5,139)(W(M),M=1,NVAR)
      DSQR=0.0
      DO 142 M=1,NVAR
```

```
  142 DSQR=DSQR+W(M)*DIFF(M)
      FNVAR=NVAR
      FVAL=(FN1*FN2*(FN1+FN2-1.-FNVAR)*DSQR)/((FN1+FN2)*(FN1+FN2-2.)*FNV
     1AR)
      WRITE(5,13)
      WRITE(5,139) DSQR,FVAL
      IF(NTAG) 42,41,42
   41 NTOT=TOT
      DO 60 II=1,2
      XMEAN(II)=0.0
      DO 60 KK=1,NVAR
   60 XMEAN(II)=XMEAN(II)+W(KK)*XBAR(II,KK)
      WRITE(5,4)
      WRITE(5,139) (XMEAN(II),II=1,2)
      L1=1
      DO 40 I=1,NTOT
      Y(I)=0.0
      READ(1'L1)(DATA(M5),M5=1,NVAR)
      DO 40 J=1,NVAR
   40 Y(I)=Y(I)+W(J)*DATA(J)
      DO 161 M=1,101
      NSUM(M)=0
  161 MSUM(M)=0
      XLARG=Y(1)
      SMALL=Y(1)
      DO 140 I=1,NTOT
      IF(SMALL-Y(I)) 141,141,242
  242 SMALL=Y(I)
      GO TO 140
  141 IF(XLARG-Y(I)) 143,140,140
  143 XLARG=Y(I)
  140 CONTINUE
      XXLAR=100./(XLARG-SMALL)
      N1=NG(1)
      N2=N1+1
      DO 150 I=1,N1
      Y(I)=XXLAR*(Y(I)-SMALL)
      NN=Y(I)+1.0
  150 NSUM(NN)=NSUM(NN)+1
      DO 160 I=N2,NTOT
      Y(I)=XXLAR*(Y(I)-SMALL)
      NN=Y(I)+1
```

```
  160 MSUM(NN)=MSUM(NN)+1
      WRITE(5,5)
      DO 162 I=1,101
      X=I-1
      YMEAN=X*((XLARG-SMALL)/100.)+SMALL
  162 WRITE(5,163) NSUM(I),MSUM(I),YMEAN
  163 FORMAT(2I10,F10.4)
      WRITE(5,31)
      K=1
      WRITE(5,7)
      DO 164 I=1,10
      NN=0
      MM=0
      DO 165 J=1,10
      NN=NN+NSUM(K)
      MM=MM+MSUM(K)
  165 K=K+1
      ZN=NN
      ZM=MM
      ZN=ZN/FN1
      ZM=ZM/FN2
  164 WRITE(5,131) NN,ZN,MM,ZM
   31 FORMAT(///)
  131 FORMAT(5X,I4,F10.4,5X,I4,F10.4)
  888 CONTINUE
   42 CALL EXIT
      END

UNREFERENCED STATEMENTS
 888

FEATURES SUPPORTED
 IOCS

CORE REQUIREMENTS FOR
 COMMON      0  VARIABLES   9052  PROGRAM   1690

END OF COMPILATION

// XEQ
```

```
      FUNCTION FUN(AAA,XX,MM)
      DIMENSION AAA(9),XX(9)
      FUN=0.0
      DO 106 I=1,MM
  106 FUN=FUN+AAA(I)*XX(I)
      RETURN
      END

CORE REQUIREMENTS FOR FUN
 COMMON      0  VARIABLES       6  PROGRAM      48

RELATIVE ENTRY POINT ADDRESS IS 000A (HEX)

END OF COMPILATION

// DUP

*STORE      WS  UA  FUN
CART ID 2021   DB ADDR  519C   DB CNT   0004

// FOR
*IOCS(CARD,1403 PRINTER)
*LIST SOURCE PROGRAM
**      COMPUTER PROGRAM V
```

```
C F TEST OF SIGNIFICANCE FOR DISCRIMINANT FUNCTION ON NEW DATA
C   F TEST, D SQUARE, AB, ABC, AND DF GROUPS ON ORIGINAL VARIABLES
      DIMENSION X(400,7),N(9),M(9),SX(9),SXX(9),SY(9),SYY(9),R(9),Y(9),
     -XMM(9),XM(9),SDEV(9),
     -            YM(9),YMM(9),SUM(9),SUM2(9),SMSM(9),ZM(9)
      DATA A,B,C,D,F/'A','B','C','D','F'/
      DO 1 K=1,400
      DO 1 J=1,7
    1 X(K,J)=0
      DO 2 J = 1,9
      SX(J)=0.0
      SXX(J)=0.0
      SY(J)=0.0
      SDEV(J)=0.0
      M(J)=0
      SYY(J)=0.0
      XM(J)=0
      SUM2(J)=0.0
      N(J)=0
      XMM(J)=0
      SMSM(J)=0
      ZM(J)=0.0
      YM(J)=0
      YMM(J)=0
      R(J)=0.0
      Y(J)=0
    2 SUM(J)=0
      L=0
      MM=0
      READ(2,1000) MM,NT
 1000 FORMAT(I1,I1)
      READ(2,10) (R(J),J=1,MM),DDD,TOT
   10 FORMAT(6F8.5,F6.3,F3.0)
    5 READ(2,20) (Y(J),J=1,7)
   20 FORMAT(29X,6F3.0,5X,A1)
      IF(Y(6)-0.0)6,7,8
    7 GO TO 5
    8 IF(Y(6)-TOT) 99,98,98
   98 FND=FUN(R,Y,MM)
       IF(FND-DDD) 99,100,100
   99 GO TO 5
  100 L=L+1
```

```
      DO 15 J=1,7
   15 X(L,J)=Y(J)
      IF(X(L,6)-Y(6)) 91,91,91
   91 GO TO 5
    6 CONTINUE
      DO 9 K=1,L
      IF(X(K,7)-A)9,11,9
   11 N(1)=N(1)+1
      DO 9 J=1,MM
      SX(J)=SX(J)+X(K,J)
      SXX(J)=SXX(J)+X(K,J)**2
    9 CONTINUE
      DO 12 K=1,L
      IF(X(K,7)-B) 12,13,12
   13 N(2)=N(2)+1
      DO 12 J=1,MM
      SX(J)=SX(J)+X(K,J)
      SXX(J)=SXX(J)+X(K,J)**2
   12 CONTINUE
      N(3)=N(1)+N(2)
      DO 14 J=1,MM
   14 XM(J)=SX(J)/N(3)
      FAB=FUN(R,XM,MM)
      DO 16 K=1,L
      IF(X(K,7)-C) 16,17,16
   17 N(4)=N(4)+1
      DO 16 J=1,MM
      SX(J)=SX(J)+X(K,J)
      SXX(J)=SXX(J)+X(K,J)**2
   16 CONTINUE
      N(5)=N(1)+N(2)+N(4)
      DO 19 J=1,MM
   19 XMM(J)=SX(J)/N(5)
      FABC=FUN(R,XMM,MM)
      DO 21 K=1,L
      IF(X(K,7)-D) 21,23,21
   23 M(1)=M(1)+1
      DO 21 J=1,MM
      SY(J)=SY(J)+X(K,J)
      SYY(J)=SYY(J)+X(K,J)**2
   21 CONTINUE
      DO 26 K=1,L
```

```
      IF(X(K,7)-F)26,27,26
   27 M(2)=M(2)+1
      DO 26 J=1,MM
      SY(J)=SY(J)+X(K,J)
      SYY(J)=SYY(J)+X(K,J)**2
   26 CONTINUE
      M(3)=M(1)+M(2)
      DO 31 J=1,MM
      YM(J)=SY(J)/M(3)
   31 CONTINUE
      FDF=FUN(R,YM,MM)
      M(8)= N(3)+M(3)
      M(7)=N(5)+M(3)
      DAB=FAB-FDF
      DABC=FABC-FDF
      G1=DAB**2
      G2=DABC**2
      SFAB=((N(3)*M(3)/(N(3)+M(3)))*DAB**2/NT)/(DAB/(M(8)-NT-1))
      SFABC=((N(5)*M(3)/(N(5)+M(3)))*DABC**2/NT)/(DABC/(M(7)-NT-1))
      DO 45 J=1,MM
      SUM(J)=SX(J)+SY(J)
      ZM(J)=SUM(J)/M(7)
      SMSM(J)=SXX(J)+SYY(J)
      SUM2(J)=SUM(J)**2
      SDEV(J)=SQRT((SMSM(J)-SUM2(J)/M(7))/M(7))
   45 CONTINUE
      WRITE(5,50)
   50 FORMAT(4X,' MEANS OF AB GROUP VARIABLES ')
      WRITE(5,55) (XM(J),J=1,MM)
   55 FORMAT(1H0,1X, 6(3X,F10.3))
      WRITE(5,55) (YM(J),J=1,MM)
      WRITE(5,60) N(3),M(3)
   60 FORMAT(1H0,1X, ' NHG = ',I4,6X, ' NLG = ' ,I4)
      WRITE(5,80)
   80 FORMAT(1H0,1X, ' D-SQUARE ',5X, ' F ' )
      WRITE(5,85) G1, SFAB
   85 FORMAT(1H0,4X,F10.3,5X,F10.3)
      WRITE(5,65)
   65 FORMAT(1H0,1X, ' ABC GROUP MEANS ON DIS FUNCTION ' )
      WRITE(5,55) (XMM(J),J=1,MM)
      WRITE(5,55) (YM(J),J=1,MM)
      WRITE(5,80)
```

```
      WRITE(5,85) G2,SFABC
      WRITE(5,60) N(5),M(3)
      WRITE(5,70)
   70 FORMAT(1H0,1X, ' MEAN OF TOTAL GROUP ' )
      WRITE(5,55) (ZM(J),J=1,MM)
      WRITE(5,55) (SDEV(J),J=1,MM)
      CALL EXIT
      END
```

```
C  THIS PROGRAM READS CARDS PUNCHED AS A RESULT OF THE MATH PLACEMENT
C     TEST. IT PRODUCES A GUIDE TO HELP ADVISORS PLACE STUDENTS IN
C     THE CORRECT COURSE....
      INTEGER YN(6), FNM(6), PAGE
      DIMENSION  LNM(13), YNA(6), DATE(2), PCT(6)
      DATA YES, XNO /'YES', 'NO '/
      DATA YN, KNT, PAGE/8*0/
      WRITE (1,100)
  100 FORMAT ('ENTER 8 CHARACTER DATE - XX/XX/XX')
      READ  (6,101) DATE
  101 FORMAT (2A4)
C**WRITE HEADING
    1 PAGE = PAGE + 1
      ICNT = 0
      WRITE (5,102) DATE, PAGE
  102 FORMAT ('1' 5X'MATHEMATICS PLACEMENT RESULTS'2X,2A4,19X'PAGE'I3/
     *'0'5X'NAME'21X'1810   1600   1040   1110   1002   1001   MATH ACT
     -   HS GPA'/)
C**READ DATA CARDS - USE CARD WITH 9 IN COLUMN 80 FOR LAST CARD
    2 READ  (2,200) LNM,FNM,MI,AR,AL,TR,ARAL,ALTR,TPER,MACT,HSA,LAST,ACT
  200 FORMAT (9X,20A1,6F3.0,I2,F3.2,27X,I1,T48,A2)
C**CHECK FOR LAST CARD
      IF (LAST - 9) 3,99,3
C** INITILIZE  'NO' IN ARRAY
    3 DO 6 I = 1,6
    6 YNA(I) = XNO
C CHECK 1810 SCORE -3.53 OR TOTAL +JI
      IF(TPER-42) 21,60,60
   60 SC = -2.693*AL-2.060*TR-0.307*ARAL+5.067*ALTR
      IF(SC+3.53) 21,5,5
    5 IS = 1
C**PUT  'YES'  IN ARRAY
   10 DO 8 I = IS,6
    8 YNA(I) = YES
      YN(IS) = YN(IS) + 1
C** WRITE PRINT LINE
      IF (HSA) 19,18,19
   18 WRITE (5,300) LNM,FNM,MI,YNA, ACT
  301 FORMAT (6X,13A1,1X,6A1,1X,A1,4X,A3,5(4X,A3),6X,A2)
      GO TO 20
   19 WRITE (5,300) LNM,FNM,MI,YNA, ACT,HSA
  300 FORMAT (6X,13A1,1X,6A1,1X,A1,4X,A3,5(4X,A3),6X,A2,6X,F4.2)
```

```
   20 KNT = KNT + 1
      ICNT = ICNT + 1
      IF (ICNT - 50) 2,1,1
C CHECK 1600 TOTAL 32+OR SCORE -1.82
   21 IF(TPER-32) 22,23,23
   23 SC = -3.309*AR-9.194*AL-0.112*TR+11.905*ARAL-1.609*ALTR+2.246*
     -TPER
      IF(SC+1.82) 22,12,12
   12 IS = 2
      GO TO 10
C CHECK 1040 TOTAL 30+ OR SCORE -6.5
   22 IF(TPER-30) 13,24,24
   24 SC = -14.656*AR-17.943*TR-14.271*ARAL+27.36*ALTR+20.16*TPER
      IF(SC+6.5) 13,15,15
C CHECK 1110 SCORE 10.30
   13 SC = 0.108 * AR + 0.112 * AL
      IF (SC - 10.30) 14,16,16
C**CHECK FOR 1002 SCORE 5.02 +
   14 SC = -0.118 * AR - 0.491 * AL + 0.754 * ARAL
      IF (SC - 5.02) 180,170,170
   15 IS = 3
      GO TO 10
   16 IS = 4
      GO TO 10
  170 IS = 5
      GO TO 10
  180 IS = 6
      GO TO 10
C**CALCULATE AND PRINT STATISTICS
   99 DO 17 I = 1,6
   17 PCT(I) = FLOAT(YN(I)) / FLOAT(KNT) * 100.0 + 0.05
       WRITE (5,400) DATE,YN,KNT,PCT
  400 FORMAT ('1'10X'TOTAL STATISTICS'2A4/'OHIGHEST CHOICE  1810   1600
     *1040   1110   1002   1001   TOTAL'/'OCOUNT'9X,7I6/'OPERCENT'7X
     *,6F6.1)
      WRITE (5,401)
  401 FORMAT ('1END OF JOB'/)
      CALL EXIT
      END

UNREFERENCED STATEMENTS
  301
```

VITA

Emery George Gathers

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